POWER PLANT ENGINEERING

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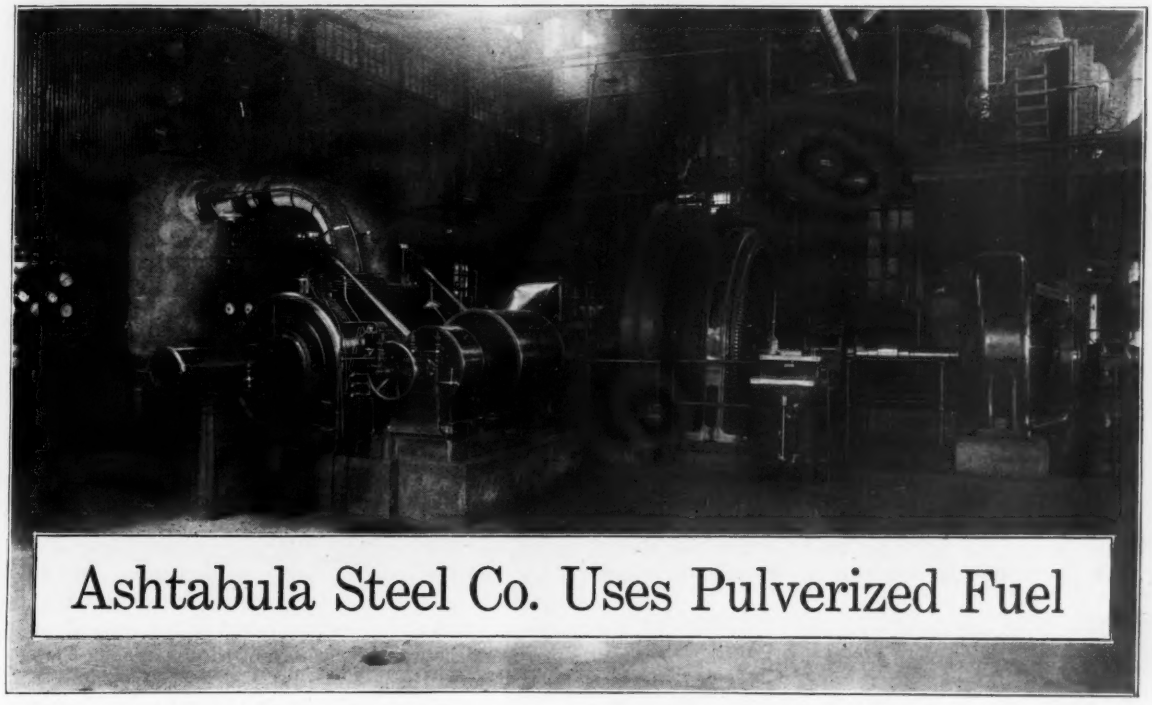


Ashtabula Steel Co. Uses Pulverized Fuel

OPERATING DIFFICULTIES EXPERIENCED AT FIRST HAVE BEEN ELIMINATED; ENGINE AND BOILERS LOCATED IN SAME ROOM

AT THE time the Ashtabula Steel Co., of Ashtabula, Ohio, was organized in 1921 for the purpose of building a plant for the production of steel sheets, considerable thought was given the subject of fuel for the annealing and sheet and pair furnaces as well as the power plant. It was finally decided that pulverized coal would be used throughout and the plant was accordingly designed and equipped for preparing and using this fuel, the work being completed and the plant placed in operation during the summer of 1922.

Although some operating difficulties have been encountered, these have been eliminated by slight changes in the methods used. At first some trouble was experienced with slagging on the tubes of the boilers. As each boiler is fired by a single horizontal burner, it was thought that the trouble might be partly due to the fact that the inferior particles of coal were blown up against the tubes. Accordingly a small high pressure steam nozzle was placed just above each burner and the jet directed downward. This seemed to aid in the distribution of combustion and the slagging trouble was materially reduced.

In this connection the soot blowers were also an aid since it was found that by increasing the number of soot blowing periods in the 24-hr. run the tubes could be kept cleaner. Present practice is to blow four times during this period.

Aside from the slag trouble, considerable difficulty was experienced in cleaning out the furnace. When the installation was made, it was specified that the sand bed on the furnace floor was to be 3 in. thick. It was found, however, at the time of cleaning the furnace that this sand had fused onto the furnace floor and required a good deal of work for its removal. In fact, the furnace was out of commission about three days for the cooling down and cleaning operation.

In working out a solution for this problem, H. C. McGaughey, master mechanic of the plant, increased the sand bed to a depth of about 12 in. It was found that some 4 in. of this bed fused into a hard slag which, if broken up with picks, was a laborious operation on account of the heat unless considerable time was allowed for the furnace to cool down. Even so the improvement over the thin sand bed was marked.

Further study evolved a scheme which has been used

FIG. 1. COAL IS PREPARED IN THIS PULVERIZING PLANT

At the left the indirect fired drier is shown. The furnace of this drier is fired with pulverized coal. The view on the right is taken looking toward the two pulverizing mills. From the mills the pulverized coal is conveyed by pumps. These pumps are of the screw type, the pulverized fuel being picked up by an air blast as it leaves the pump.

with success and which has reduced the time for cleaning. The secret of this method is the injection of water under the hot slag bed. As soon as the plant is shut down on Saturday, a pipe, with a hose connection attached, is inserted under the sand bed through the clean-out doors. Water is allowed to flow into the sand for several hours, the position of the pipe being changed from time to time.

FIG. 2. BOILERS ARE FIRED BY SINGLE HORIZONTAL BURNERS OF THE FLARE TYPE

As the water comes in contact with the hot sand, steam is generated under the slag bed and the pressure breaks up the bed into pieces which can be handled. At the same time, this water aids in cooling down the furnace.

It has been found that two men can take out all the slag of a two weeks' run and put a new sand bed back into the furnace in 4 hr. working time, after the slag has been broken up. Eight sheet furnaces are cleaned in the same way by four men in 8 hr.

Originally the burners on the sheet and pair furnaces were of a flat type. These were replaced with an ordinary piece of 3-in. pipe with a rectangular air jet just below the pipe to aid in the distribution of combustion.

Coal Preparation Is Handled in a Separate Building

Coal is prepared in a separate building from the power plant. When the coal is received it is dumped into a hopper of one-half car capacity which feeds a 24 by 24-in. Pennsylvania single roll crusher which has a capacity of 30 to 40 T. per hr. This crusher is belt driven by a 35-hp., 900-r.p.m., 220-v. alternating current slip ring motor. Coal is crushed so that 75 to 85 per cent will pass a 1-in. square opening.

From the crusher the coal is elevated by a Webster elevator to a 25-T. storage bin. This elevator is driven

by a 15-hp., 900-r.p.m. induction motor, also of the slip ring type. From this storage bin it feeds to a 3-ft., 6-in. by 30-ft. indirect fired coal drier with a capacity of 6 T. per hr. This drier is rotated by a 5-hp., 1200-r.p.m. slip ring motor. To provide a steady flow of coal through the drier a cradle feeder is used which is driven by a 2-hp., 1200-r.p.m. slip ring motor. Air is supplied to the drier by a Buffalo Forge exhaust fan driven by a 5-hp., 1200-r.p.m. induction motor, which draws the gases through the furnace and through the drier. Any fine particles of coal which may be carried by the air are separated out in a cyclone dust collector and pass to either of the bins just above the pulverizing mills.

From the drier the coal passes on to a second elevator which elevates the dried coal to either of two 3-T. storage bins which are located just above the pulverizing mills. This elevator is also driven by a 5-hp., 1200-r.p.m. slip ring motor.

From the storage bins the coal is fed by gravity into two Fuller mills, one of which is normally held in reserve. These mills are driven by 75-hp., 450-r.p.m. motors. One of the motors is of the induction type and the other is a slip ring.

FIG. 3. THIS FAN SUPPLIES AIR TO THE LINES SUPPLYING THE BURNERS

It has been the experience of this plant that the slip ring motor is better adapted to this service than straight induction type.

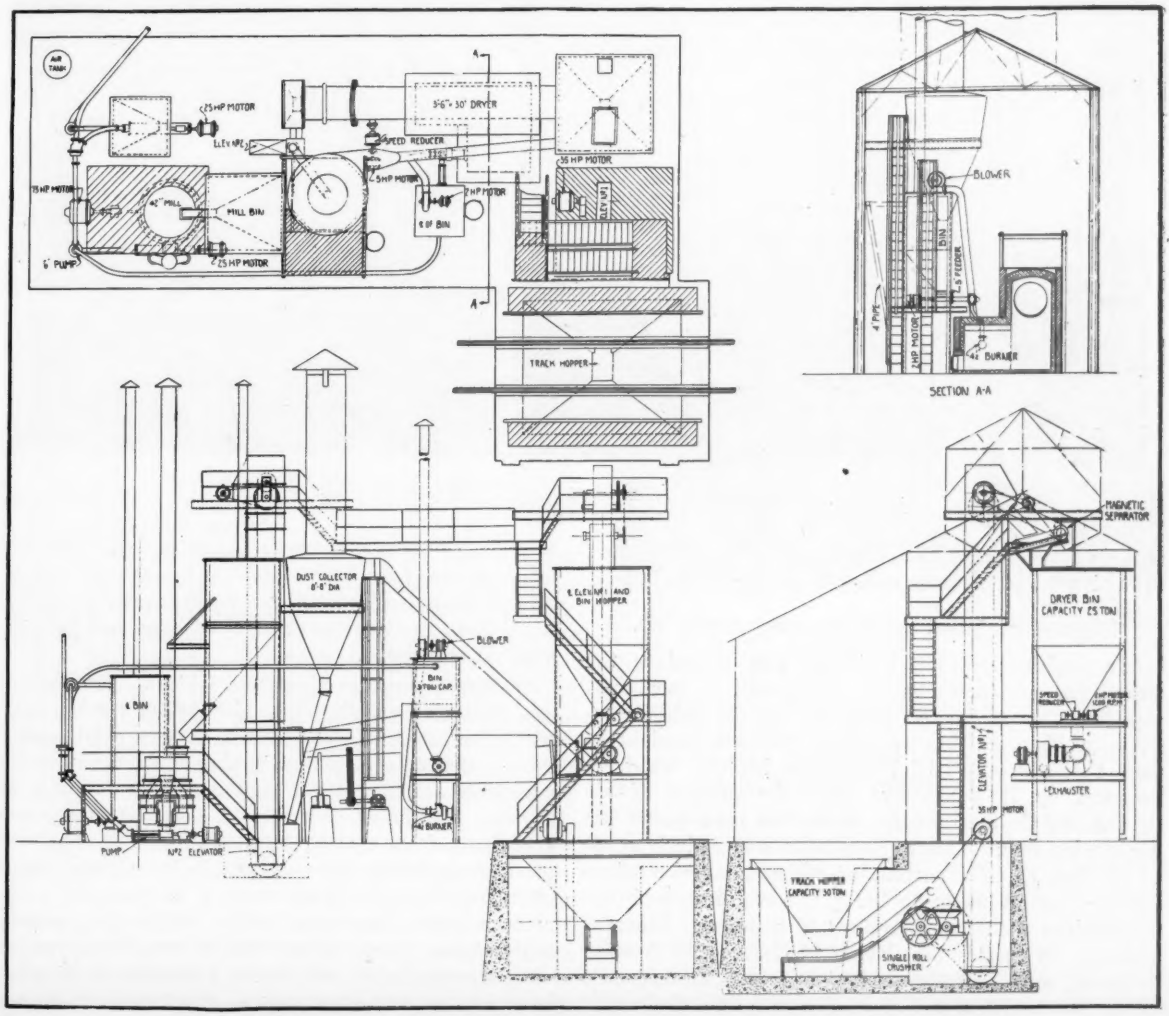


FIG. 4. LAYOUT OF THE PULVERIZING PLANT SHOWING THE SEQUENCE OF OPERATION

After the coal is pulverized, it is conveyed by a Fuller-Kinyon pump to the weigh bin. This Kinyon pump is driven by a 25-hp., 900-r.p.m. slip ring motor. From the weigh bin the coal is distributed to the furnace and to the boiler storage bins by another Kinyon pump of the same size.

There is a 25-T. storage bin for the annealing furnace. This furnace has eight burners and each burner has its own feeder motor. Each motor is a 2-hp., 500 to 1500-r.p.m. direct current, shunt wound machine. There are two fans, one of which is held for a spare, driven by 5-hp., 1700-r.p.m. direct current, shunt wound motors.

Each sheet and pair furnace, of which there are eight, has a 4-T. storage bin and a 2-hp., 500 to 1500-r.p.m. direct current feeder motor. There are eight Buffalo Forge fans, each driven by a 7½-hp., 1800-r.p.m. induction motor. The air pressure in these lines is 6 oz.

Superficial Moisture Is Removed from Coal

In drying the coal, it is the aim to reduce the superficial moisture content to around 2 per cent, although this varies somewhat due to the initial condition of the coal. By way of explanation, it might be said that the superficial moisture is that which is removed by the ordinary laboratory process of air drying and is that weight which has been called the air drying loss. This drying is generally done at 30 to 35 deg. C. in a current of air and is intended to remove enough water to bring the coal into moisture equilibrium with the laboratory atmosphere. Inherent moisture in coal is that which is removed by heating a ground sample of the air-dried material in a crucible in an oven at 105 deg. C. for one hour. It is the weight which is obtained as moisture in an analysis.

It seems to be superficial moisture which affects the pulverizing, transporting and feeding equipment in pulverized fuel plants. The present tendency is to guarantee performance on a 3 per cent moisture basis and this is understood to refer to superficial moisture only. Air-dried coal may contain anywhere from 0.6 per cent to 15 per cent moisture, depending upon its character and source. Therefore if 3 per cent moisture be the proper guaranteed figure, coal as fed to pulverizing equipment may contain anywhere from 3.6 per cent to 18 per cent total moisture and still give satisfactory results.

Boilers and Engine in One Room

One feature of the power plant which deviates from usual practice is the fact that the boilers are located in the same room with the generating unit. This indicates, as has been found from the experience at this plant, that pulverized fuel compares favorably with gas or oil from the standpoint of cleanliness and ease with which it is handled.

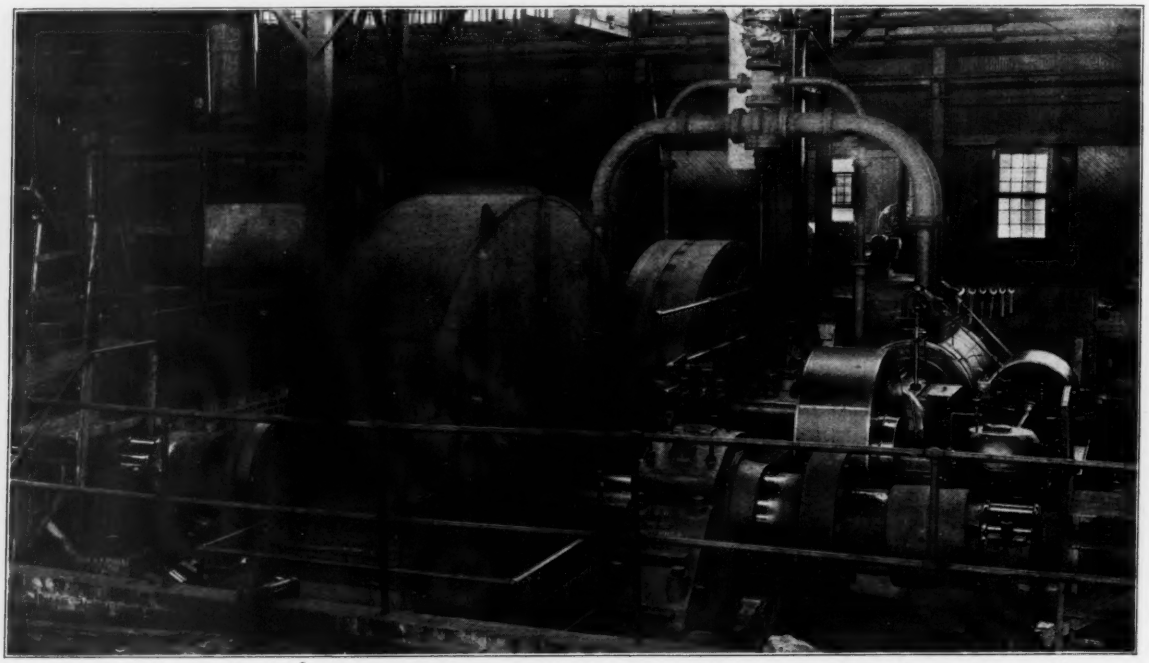


FIG. 5. DUPLEX UNIFLOW ENGINE WHICH DRIVES THE SHEET MILLS

Before the power plant was laid out, consideration was given to operating the mills by an electric motor with purchased current, but a very careful analysis showed that a large annual saving could be effected by installing a boiler plant and a uniflow rolling mill engine. Purchased current was available at a reasonable figure from a new central station; but even under the most favorable circumstances it is ordinarily impossible for central station current to compete with a modern boiler plant and uniflow engine for operating mills of this type. Consideration was also given to a motor-operated mill with power generated in the plant; however, this was abandoned as power can be developed as economically in the cylinder of the uniflow engine

as in a turbine or engine driving a generator and by connecting the engine directly to the mill the conversion losses of the motor and generator are avoided.

After it was decided to install an engine on the mill it was, of course, much more economical to install a unit for the generation of electricity for the remaining mill load rather than purchase this current.

Two 443 hp. Union Iron Works horizontal water tube boilers, equipped with Foster Superheaters, supply

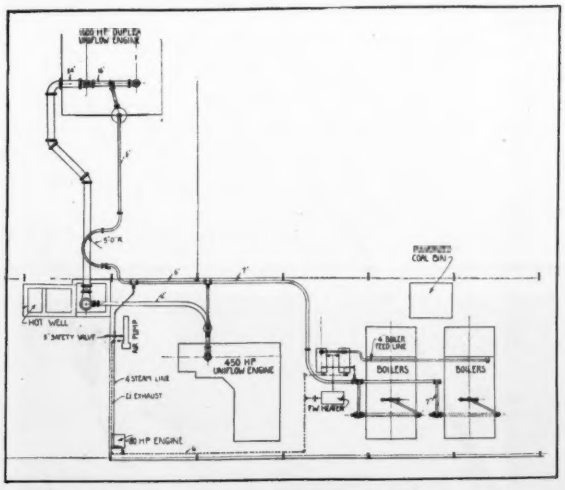


FIG. 6. SIMPLICITY IS A FEATURE OF THE POWER PLANT LAYOUT

steam at 180 lb. and 100 deg. F. superheat to the power plant and mill engines. As will be noted from Fig. 2, these boilers are fired by a single fan tail burner, set horizontally in the front wall of the furnace.

Pulverized coal is fed to the burners from a storage bin located in front of the boilers. There are two direct current feeder motors, one for each burner. These motors are 3 hp., 220 v., shunt wound, with a speed range from 500 to 2000 r.p.m. Speed regulation is by a 1600-ohm speed rheostat cut into the shunt field circuit. For starting, standard shunt field starting boxes are used.

This variation of speed in the feeder motors is necessary because of wide fluctuations in boiler load in an industrial plant of this type.

Air is supplied by a Buffalo Forge fan which is driven by a De Laval turbine shown in Fig. 3. It is necessary that this fan be turbine-driven in order to start up the plant.

For this starting duty a 50-hp. Union Iron Works fire tube boiler of the portable type, operating at 125 lb. pressure, is used. In addition this boiler supplies steam for a 60-kw. Buffalo vertical engine generator set which may be used for emergency lighting service and for driving the feeder motors at the time of starting up the plant.

Although the burning of pulverized coal does not cause soot as it is ordinarily thought of, the fine ash is in the form of a yellowish powder which tends to collect on the tubes. For the removal of this dust Vulcan soot blowers are used, located in the same positions as for a soot blowing installation. As previously mentioned, these units have aided in the reduction of slagging on the tubes.

In addition to cleaning out the furnace every two weeks, the drums and water legs are washed out at the same time. Since the water supply is good, not much trouble is caused by scale and it has been found unnecessary to turbine the tubes oftener than once every six months.

Feed water to the boilers is handled by two Worthington 10 by 6 by 10-in. reciprocating boiler feed pumps, one of which is used as a spare. The feed water is heated by a Cochrane open V notch metering heater with a capacity of 31,500 lb. per hr. Exhaust from the boiler feed pump, air pump and turbo-blower is used for heating, although the supply is hardly adequate as the feed water temperature is normally about 160 deg. F.

Control of the feed pressure is taken care of by "S-C." pump governors and "S-C." feed water regulators are used.

This boiler equipment supplies steam to two uniflow engines, one of which is located in the power plant and

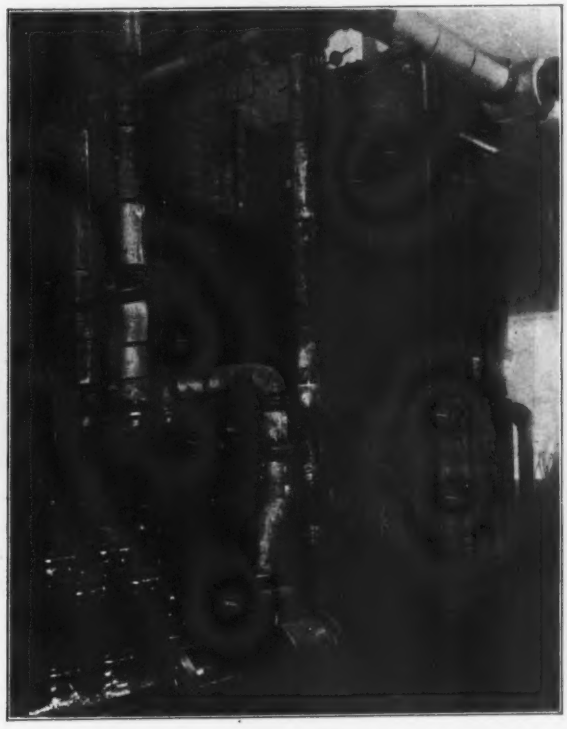


FIG. 7. FEED WATER IS HEATED BY THIS OPEN TYPE METERING HEATER

the other in the sheet mill. The power plant engine is a 750-hp., 150-r.p.m., 22 by 32-in. Nordberg which is direct connected to a 350-kw. General Electric Co. alternator and to a 175-kw. Crocker-Wheeler direct current generator.

Such an arrangement of a unit for supplying both direct and alternating current from two units direct connected to the prime mover is somewhat unusual but has certain practical advantages since it eliminates the use of a motor-generator set.

For the sheet mill drive a 1600-hp., 28 by 28 by 36-in. Nordberg duplex uniflow engine is used. The engine drives the main shaft through a Falk herringbone gear.

There are eight finishing stands, five roughing stands and four cold rolls which are driven by this engine. The battery of finishing stands is made up of four with 38-in. length rolls, two with 42-in. rolls and two with 46-in. rolls. While the engine for this drive has a rating of 1600 hp., it will carry a momentary overload of 3000 hp.

Although the power plant engine may be run non-condensing in case of an emergency, it is normally operated condensing. Exhaust steam from both this engine and the mill engine pass into the Ingersoll-Rand counter-current barometric condenser shown in Fig. 8.

Cooling water for this condenser is drawn from a cooling pond which is equipped with four stands of 30 Binks spray nozzles. The water is circulated through the condenser by a 1600-g.p.m. De Laval centrifugal pump and the cooling pond sprays are operated by a 2000-g.p.m. centrifugal pump of the same make. Both of these pumps are mounted on one base and are driven by a single 40-hp., 1200-r.p.m. Allis-Chalmers induction motor. A view of this unit is shown in Fig. 8.

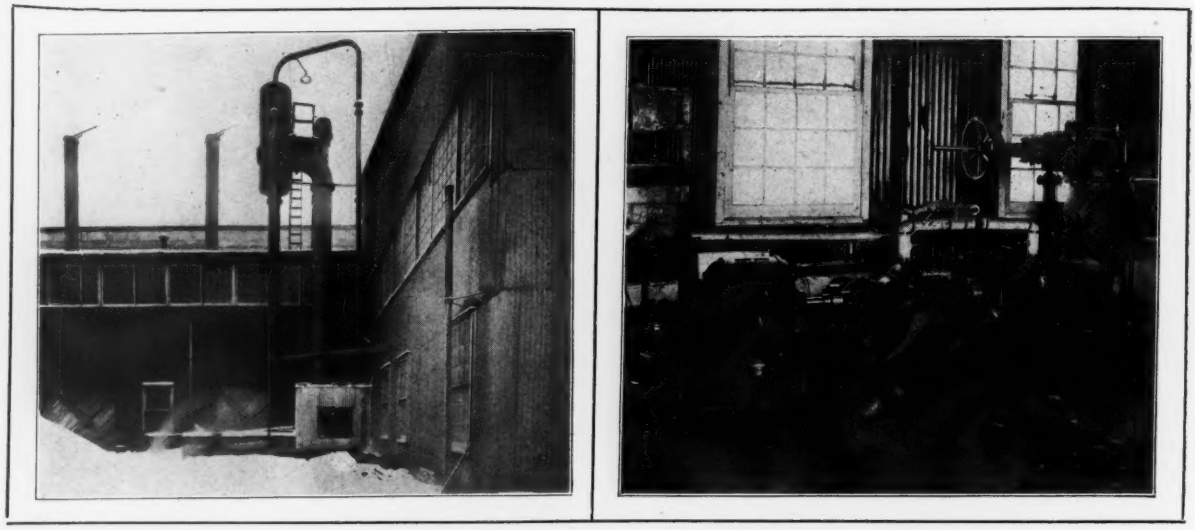


FIG. 8. BOTH ENGINES EXHAUST INTO A BAROMETRIC CONDENSER

At the left is a view of the barometric condenser while at the right is shown the circulating pumps. The larger pump of the two circulates the cooling pond water through the spray nozzles while the other pump circulates the condenser water through the barometric condenser shown at the left. Both the mill and power plant engines utilize this condenser.

In connection with this method of maintaining a vacuum it is interesting to note the simplicity of the power plant layout. The plant consists of one ground floor room, with no partition between the boiler and the engine. No space of value is occupied by the condenser as it is located outside of the building.

Other considerations which led to use of this type of condenser besides the saving in building space were that the one condenser could be used for the two engines; the equipment is simple, maintenance cost low and no hot well pump required; less water is required than for a surface condenser and less power is required for pumping.

On the other hand there are certain disadvantages with the use of the barometric condenser. Long exhaust pipes are required which increase the possibility of air leaks. The condensate is wasted with an increased cost for heating the feed water.

This latter point is especially important for, as previously mentioned, the feed water under normal operations is about 160 deg. F.

At a later date, it is planned to install a turbine on the circulating pumps at the end opposite the motor, which will permit the operation of either or both of these pumps by either the motor or turbine. This will give a very flexible arrangement for securing proper heat balance and simplify starting up the plant. Before this change is made, general tests will be conducted to determine the desirable economy of the circulating pump turbine.

Referring to Fig. 8 showing the barometric condenser, it will be noted that the air suction pipe leaves at the top. The large vertical pipe at the right is the exhaust from the engine while the smaller pipe entering at the upper center of the condenser is the condensing water inlet. The tail pipe is the larger vertical pipe leading from the condenser.

Steam enters from the exhaust pipe and is condensed by contact with the spray of water coming down from above. Air and non-condensible vapors pass upward through the falling water and are finally removed from the top of the condenser shell by the Ingersoll-Rand vacuum pump.

Although it has not been possible to run a complete test on the plant to determine actual efficiencies, the performance has been entirely satisfactory. As far as the coal consumption per ton of finished product is concerned it is known that this is lower than other plants of a similar type.

It has been found that pulverized coal is easy to handle and requires a minimum amount of attention in the boiler room even under fluctuating load conditions.

This plant was designed by the Dravo-Doyle Co. of Cleveland in conjunction with the engineers of the Ashtabula Steel Co. In the preparation of this account we are indebted to Robert Lock, president, and H. C. McGaughey, master mechanic of the Ashtabula Steel Co., and to W. K. Fitch, district manager of the Dravo-Doyle Co., for assistance in securing the information.

Gaskets and Packing, and How to Use Them

Substantial Savings May Be Made by Proper Selection and Installation. By C. A. Underwood and J. R. Darnell

IT MAY BE surprising to learn that many power plant operators know comparatively little about the proper use of gaskets and packing. Too much is often left to chance or the policy that any old thing is good enough. The man who does not know and makes no effort to learn is very little better than one who knows but does not care. As regards such an apparently humble thing as gaskets and packing, there is little wonder that employers and owners are indifferent when operators are not awake to the situation. Plant owners would stand aghast if they could be shown the enormous sums which are wasted each year through improper selection and use of gaskets and packing. Final analysis shows, as it almost always does, that the best even though highest in price, is eventually the cheapest; the difference of a few cents per pound between inferior material and that of good quality may mean many dollars in the end.

Large plants which employ the services of purchasing agents are oftentimes unwittingly the greatest sufferers. Quite often the agent and his assistants are totally ignorant of all power plant equipment and to them a valve is a valve, a pump is a pump and one gasket is as good as another. They buy in the cheapest markets regardless of quality and think they are saving the company money, and quite often they make the owners think so too. However, the most incomprehensible part of the whole situation is the plenary powers given to the purchasing agent, for he is the real autocrat of the power plant. The engineer should be paid for what he knows, but such recompense is wasted if his recommendations are disregarded as they so often are.

As a general topic sentence upon which subsequent discussion will be based, let us begin by saying that there is a particular kind of gasket material and packing for every need. To elaborate sufficiently upon these needs, this article will be divided into such main topics as steam, water, ammonia, gas and air, light and heavy oils, acids and alkalies, brine, and metallic and carbon packing.

Steam—High Pressure and Superheat

All gasket material found successful for this kind of work has asbestos as a base. The asbestos for this purpose should be of long fiber which, when well pressed together, will give great tensile strength to the material. Asbestos sheet made up in this way is very hard to tear; in fact, a good sheet cannot be torn with the bare hands. It is not absolutely necessary that the material be impregnated with graphite; but when the gasket is placed in position, one side should be coated with a mixture of graphite and cylinder oil if the joint is to be broken frequently. If the connection is to be permanent no lubricant should be used, and the gasket will then cement itself to the metal; thus making the union more secure.

Rubber sheeting or compounds of rubber and other materials do not make good gaskets for high temperatures because of vulcanization of the rubber. When the latter is vulcanized it loses its elasticity and tensile strength and shrinks appreciably. Flanges so equipped must invariably be drawn tighter after becoming hot or the joint will leak. Such work is a nuisance besides being an added expense.

Gaskets especially intended for high pressure steam should be made as thin as the condition of the surface will permit. For machined surfaces, 1/32-in. material will give the best results if the joint is carefully pulled together; thick gaskets leave a weak joint and require a second tightening. To function properly all gaskets must have a certain degree of elasticity which will allow enough compression to fill the pores of the metal surfaces upon which they are placed; beyond this any thickness of material only weakens the joint. That portion of any gasket which does not become an intimate part of the metal which it touches should be reduced to a minimum, for it gradually loses its elasticity with age and becomes hard and dry.

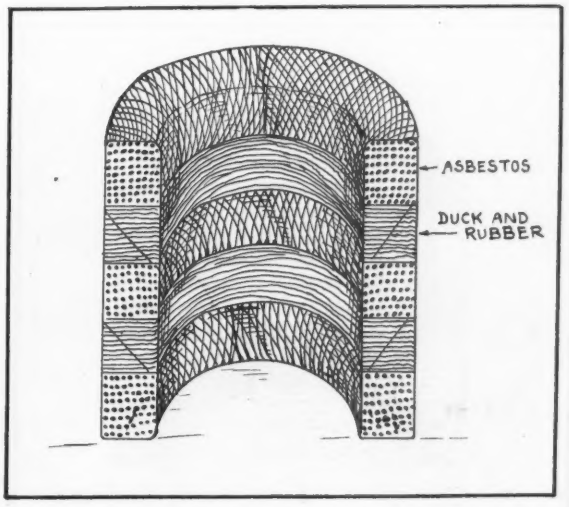


FIG. 1. SATURATED STEAM PACKING IS MOST SATISFACTORY WHEN MADE OF ALTERNATE RINGS OF ASBESTOS AND DUCK AND RUBBER

Packing for high pressure and superheated steam service should be of the same quality as the gasket material in that asbestos should be the basis of its composition. The fibers should be long and free from hard spots or knots. This packing should be of fine strands, closely braided, yet not so close as to cause the rings not to be pliable. Cushion ring packings may be purchased for use on worn rods; however, this is not reaching the source of trouble. If proper precautions are taken, a rod will wear appreciably only after years of service. Packing material strands should be well covered with graphite, and after this has worked into the interstices between fibers the whole surface of the packing will assume as smooth a surface bearing on the rod as the rod itself. If such packing is always used friction will be reduced to a minimum and long life of the rod assured.

Care should be exercised in tightening packing glands even though the best grades of packing be used. A good rule to follow is to pull the packing up snugly with a

wrench, back off the nuts until perfectly loose, then tighten again with the fingers. Glands packed in this fashion seldom require further attention.

Next to quality, probably the most important consideration in selection is correct size. It should always be of such diameter that it will just fit into the gland-box and should be cut short enough to allow for expansion. The length, of course, must be left to the judgment of the operator. The larger the rod the greater should be the allowance for expansion; for instance, a packing ring for a rod 1½ in. in diameter should be cut about ⅛ in. short. The unforgivable sin in the correct methods of packing operation, strange to say, is probably the most common fault. It is hard to figure out why operators, even where a large selection of sizes is available, will calmly overlook the correct size and select a packing much too large for the stuffing-box,

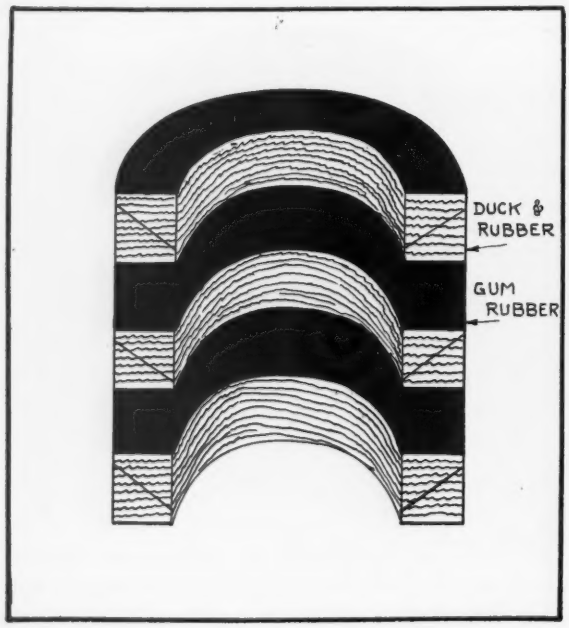


FIG. 2. ALTERNATE RINGS OF GUM RUBBER AND DUCK AND RUBBER MAKE GOOD AMMONIA PACKING

then in order to reduce the size, use a hammer and pound away with an ardor worthy of better judgment. The homogeneity of the material is thus destroyed and some spots are made much more dense than others. These hard spots soon cause excessive friction and the the uneven wear at these points scores the rod. It should be noted that packing expands in diameter as well as in length so that even if it has not previously been hammered but is forced into the gland-box, trouble from overheating will result.

Medium Pressure and Saturated Steam

Gaskets for operation with this condition should be of the same quality as prescribed for higher pressures and temperatures; but in the selection for this service, distinction should be made between packing which is to be used for dry saturated steam and that containing moisture. With dry saturated steam, the same packing may be used as with superheated steam, but when moisture is encountered, pure, loosely woven asbestos will not give entirely satisfactory service because water disintegrates asbestos and leaves a soft spongy mass. For moist steam service it has been found best to use a combination packing consisting of graphited asbestos placed in direct contact with the steam and this followed with a packing made of rubber and duck cement together. The asbestos and rubber-duck packing are then placed in alternate layers, the purpose of which is two-fold. The graphited asbestos withstands heat and reduces friction, while the rubber-duck prevents water leakage. For large rods it is a good plan to use the combination just described, but with the rubber-duck packing cut so as to form a wedge which will adjust itself readily to the rod. This is shown in Fig. 1.

Low Pressure Steam

With low pressure steam, gaskets may be made of sheet rubber for the reason that with the lower pressure the temperature is also lower, consequently the rubber does not vulcanize so readily. In the selection of gasket material, all too many power-plant owners think only of the initial cost. If this alone is considered, rubber is much cheaper than asbestos; however, rubber does not last. The fact that when asbestos is used a joint can be pulled up tight and kept tight, while rubber at each tightening squeezes out and loses its resiliency, makes asbestos the more desirable and in the last analysis, cheaper than rubber for almost all kinds of gasket service.

In the use of asbestos gaskets for steam or water there is only one precaution which should be observed—always make sure that the flanges are drawn up tightly enough to prevent moisture from getting in between the surfaces of the gasket and the flanges. Water will ruin asbestos if much surface is exposed. Packing for low pressure steam should be the same as that used for medium pressure.

Cold Water

For pressures up to 300 lb. gaskets of rubber sheeting give good service. For hydraulic press work, gaskets of hard fiber should be used. The best all-around packing for cold water is square flax, and combinations of rubber and duck also give good service. Tightly braided flax, well graphited, should be used for hydraulic press work, in fact, it is the only packing worth consideration for this service.

Gaskets for use on high pressure hot water lines should be cut from hard sheet asbestos. Rubber gaskets may be used with good results on low pressure hot water lines, but as previously pointed out, it is only advisable where initial cost alone must be considered. Observe the same precautions in keeping water from the surface of the gasket as with steam. Packing for hot water service should be made of pure duck or a combination of duck and rubber. Pure duck rings for inside packed pumps are probably the best for either hot or cold water with pressures up to 200 lb. The combination of duck and rubber for stuffing-boxes and outside packed pumps is very reliable. Square flax is the universal water packing, and if properly used it is the cheapest and most trustworthy of all material for this service. It should be remembered, however, that square flax undergoes considerable expansion when heated, therefore it is very poor practice, for instance, to force ⅝-in. material into

a stuffing-box requiring ½-in. packing, for trouble will invariably result. Friction will soon cause the flax to become charred and when this happens the pump rod or shaft will be scored if the old packing is not removed at once and new flax inserted. Hot water provides hard service for any kind of packing and extreme care must be exercised if long life is to be expected. The brass sleeves found on many centrifugal pumps should be replaced when worn if the packing is expected to give good results.

It is poor policy to buy an inferior grade of flax packing for no other reason than cheapness, for it will usually be found to contain hemp. Careful inspection will usually disclose the coarse, rough texture of the hemp by both its appearance and the harsh feeling imparted when rubbed across the back of the hand. Pure flax is soft and silky and has considerable tensile strength; on the other hand, hemp can be pulled apart very easily. The attendant cost of repeated packing renewals ought to teach anyone the folly of buying substitutes for real flax packing.

Ammonia

Gaskets for this service should be the same as recommended for superheated steam, especially for hot lines; however, rubber can be used very successfully on low pressure and cold lines.

Packing for ammonia service must withstand severe treatment because ammonia gas has a decided alkaline reaction and is therefore corrosive. Much is dependent on the strength and security of the packing. Even a small leak is obnoxious and if not given attention at once may become quite dangerous. This demands packing that will not fail.

Combinations of rubber-duck and pure gum rubber give the best results. The gum provides the resiliency necessary to prevent leaks while the rubber-duck gives the necessary strength to stand continued service. Figure 2 illustrates a very good method of packing. This shows, in half section, five rings in the order in which they should be placed in the gland; the rubber-duck is first placed at the bottom and then alternate layers of pure gum and rubber-duck.

Gas and Air

Where air or gases are cold, gaskets made of a good grade of sheet rubber give excellent service and are inexpensive. Hot gases, such as producer and coke oven gas, require asbestos gaskets. For compressor service, with both gas and air, the temperature developed necessitates a good grade of asbestos.

Where no appreciable temperature is encountered packing for air or gases should be the same as that recommended for ammonia. (See Fig. 2.) For air and gas compressors the best grade of asbestos packing should be used. Such service provides the most severe test for even the best of packing materials as the dry heat naturally tends to harden and make brittle any packing that may be used.

Most manufacturers of packing offer a packing with a rubber filling which, it is claimed, serves as a cushion and provides the necessary resiliency; but for hot air and gases, this has not been found as satisfactory as long-fibered asbestos braid, well lubricated with graphite.

Light Oils

Under this topic is included such oils as benzine, gasoline, kerosene and naphtha. All of these require the best grade of asbestos for both gaskets and packing. The asbestos should be thoroughly impregnated with graphite, because when so treated it is not readily attacked by oils and will give far better service than most

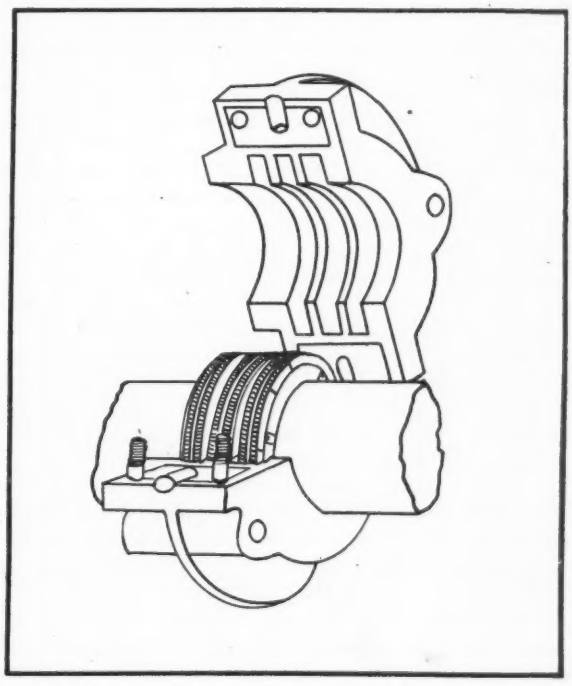


FIG. 3. METALLIC PACKING SHOULD BE USED ON ALL LARGE RECIPROCATING RODS

of the widely advertised combination material. A great many of the brands of so-called "sure-tight" packing employ mixtures of asbestos and paper pulp, but low price is about all that can be said in favor of such packing.

Recently there has come to the attention of the authors, an instance where a centrifugal pump handling crude benzine (crude gasoline) was packed with ordinary asbestos rope dipped in a mixture of graphite and oil. The job was hurriedly done by a pipe-fitter who did not know what else to use, yet he unwittingly selected the right material and today, after almost 6 mo. continual service, the glands show no sign of leakage. Prior to this time every Tom, Dick or Harry who tried to pack this particular pump thought he must use square flax and the result was that the pump incessantly leaked or was found with hot glands.

Heavy Oils

Where flanges are smooth, it has been found that paper provides the best material for gaskets in the handling of heavy oils. A coating of shellac on each side of the gasket will greatly prolong life by keeping the oil from penetrating the fibers. For old or rough surfaces, sheet asbestos impregnated with graphite should be used. Flax is probably the best material for packing, although candle wicking has been found to give excellent service and is not so expensive.

Acids and Alkalies

For these chemicals, there seems to be some difference of opinion as to which material provides the best service. In quite a number of cases, rubber has given excellent results although for the most part asbestos will probably give the longer service. For packing, rubber combinations quite often serve the purpose but as with gaskets even better results are obtained with firmly braided asbestos well lubricated with graphite, because asbestos is not readily attacked by ordinary acids or alkalies.

Brine

Rubber gaskets give excellent service. For packing, however, square flax should be used as rubber combinations do not last very long. When in direct contact with brine, the rubber used in this material becomes hard and brittle and the glands soon leak.

Metallic Packing

This packing may be successfully employed and is really advisable for all large rods exceeding 3 in. in diameter. It is to be especially recommended for all large reciprocating machines if experienced and careful operators are in attendance. If good results are to be expected with metallic packing, the rod must not be worn and should have a smoothly polished surface.

In almost all cases it is recommended that the bearing segments be made of the best grade of soft gray cast iron, free from pores or sand holes. Such iron easily acquires a highly polished surface which minimizes friction and so reduces the wear on the rod. If there is much condensation, it is advisable to use bearing rings of a softer metal, although cast iron will give satisfaction if the rod is well lubricated with a mixture of graphite and cylinder oil.

Metallic packing especially designed for piston rods is made to fit inside of a split case in order to facilitate the renewal of the packing segments. Perfect freedom of lateral movement with very little friction is obtained by making the packing fit the case and the rod.

If a competent machinist can be employed, it would be both advisable and profitable for most plants to make their own metal packing. Figure 3 shows a design of metal packing which in the experience of the authors meets almost all requirements of ordinary operation and which is readily accessible if repairs are to be made. There is entire freedom of rod movement and very little friction. It should be especially noted that this is not a wedge-packing which is always in danger of causing undue heat if the wedges are not cut with the correct angle of contact.

Carbon Packing

Carbon packing may be contrasted with metallic in that the former is to be used on revolving shafts while the later is to be used on those which slide. Carbon packing would be easily broken by the thrust of sliding rods while metal would develop much more friction on shafts revolving at high speed than carbon.

Carbon sectional rings are used on steam turbine glands. This packing has long life, often lasting for years without renewal. High speed soon causes the carbon to become highly polished and the small amount of friction generates very little heat. Quite often carbon packing contains enough graphite to permit some degree of lubrication; but if too much graphite is used, the packing is too soft to withstand much wear.

Should the carbon segments become worn to such extent that the ends are brought together, thus holding the bearing surface off the shaft, the ends should be carefully dressed until there is a slight clearance between each two segments at this point. Carbon packing is held in place by springs which permit slight lateral movements of the shaft yet allow no leakage through the gland.

Briefly scanning the salient points disclosed in the preceding paragraphs it is shown quite clearly that asbestos is the most suitable of all materials which may be considered for gasket service. For packing needs, it is also in almost as great demand. Along with asbestos, square flax serves a multitude of purposes.

Of equal importance with quality are proper methods of packing. Competent workmen must be employed if satisfactory results are to be obtained, even though the best of material be used. Quite often this point is overlooked and ordinary laborers, careless and unskilled, are entrusted with packing jobs which only an expert should undertake. Experience, good judgment, and a large dose of common sense are prerequisites to successful gasket and packing installation. Scored rods are often mute evidence of lack of such essential qualifications.

Before inserting new packing, every bit of the old should be removed. This must always be carefully attended to if good results are to be expected. Crowding in new packing on top of old is a waste of time and money as any one who has ever been guilty will testify.

Proper packing tools are important. Suitable steel hooks are necessary in removing old packing; however, a steel rod should never be used to drive in new packing, for the steel may score the rod and is quite likely to tear the fibers, change the uniform density of the material, and so nullify all previous care in selecting proper material. If the correct size of packing has been chosen, it will not be found necessary to use anything heavier than a piece of wood to push it in place.

Manufacturers ordinarily supply packing in sizes varying by 1/16 in. If they, who have given the subject careful consideration, have deemed it necessary to offer such a large range of sizes, the purchaser ought assuredly to take advantage of the opportunity. Carefully measure the gland and order accordingly.

Gaskets and packing are important items of expenditure in almost all plants. The details herein discussed should be given serious consideration if savings in plant operation are to be expected.

Gravity of oils is expressed in terms of specific gravity or Baumé gravity. The specific gravity of oil is expressed as the ratio of its weight with the weight of an equal volume of distilled water. Since both oil and water expand or contract with change of temperature 60 deg. F. is standard temperature. The hydrometer which is in general use is in the oil trade for quick and reasonably accurate determinations, may be graduated either for specific gravity or an arbitrary scale. The Baumé scale is in use by the oil industry. This scale is based on the gravity of distilled water at 60 deg. F. at which point the Baumé scale is marked 10 deg. The lighter the liquid the deeper the hydrometer sinks. Light oils have high gravity. Heavy oils have low gravities. The Baumé gravity of lubricating oils is from 19 to 35 deg. Baumé.

Determining Water Rate with Indicator Cards

A Convenient, Rapid Method of Determining Water Rate When the Usual Means Cannot Be Employed. By C. A. Joerger.

ONE OF THE frequent problems that confront an engineer is to determine the water rate of a steam engine. The usual method is so to arrange the equipment that the water rate can be determined by weighing the feed water pumped to a boiler which supplies steam only to the engine under investigation. At other times the steam coming from the engine is condensed and weighed. All such methods of obtaining water rates are expensive, take considerable time and often interfere with plant operation. The writer has frequently used the indicator card method for determining water rates of unjacketed, non-condensing engines, using relations determined by J. Paul Clayton as published in the University of Illinois Bulletin No. 58.

Recently, while making a power investigation at a large manufacturing plant, it was necessary to determine the water rate of a reciprocating steam engine, but it was impractical to shut off the steam to everything but the engine. There was no condenser. Hence, when the water rate of the engine was announced in about 20 min., the operating men and engineers were astonished and for many hours it was necessary to explain how it had been done. An evening meeting was held and the method explained. The interest shown was surprising and it led the writer to publish the particular investigation so that engineers and operators can study the method and use it in their work.

The Engine and Equipment

In this particular case the engine tested was a Brownell, enclosed single-cylinder 12 by 12 automatic, balanced slide valve engine. Its normal load was between 90 and 100 indicated horsepower.

With this method a standard indicator is necessary. In this case, two indicators were used, one on each end, this being done so that the pipe connection between the cylinder and the indicator might be as short as possible. An accurate reducing motion is also essential and the clearance volume of the cylinder on both ends must be known. In the case under consideration, it was determined by water measurement. The head-end clearance was found to be 14.97 per cent and the crank-end clearance 14.79 per cent.

The Indicator Diagrams

After the engine was running and carrying its normal load, about 10 sets of indicator cards were taken and of this lot a representative set was selected. This card is shown in Fig. 1. The first thing to do with the cards is to lay off a line A B 14.6 lb. (the barometer reading for that day) below the atmospheric line. Draw C E and D F tangent to the indicator cards and at right angles to the line A B. C D then represents to some scale the stroke of the engine and the piston displacement. Lay off A C, the head-end clearance, equal to 14.97 per cent of C D; and B D, the crank-end clearance, equal to 14.79 per cent of C D. Draw A H and B K perpendicular to A B. Draw horizontal lines every 10 lb. pressure and vertical lines every quarter of an inch.

Next, it is necessary to determine the cylinder volume represented by each inch along A B. For the case under discussion the piston displacement is 1358 cu. in., the clearance is 203. cu. in., then the total cylinder volume when the piston is on the crank-end dead center is 1358 + 203 = 1561 cu. in. or 0.903 cu. ft. This volume is represented by the distance A D which is 4.02 in., hence one inch along A D represents 0.2245 cu. ft. on the head-end. In the same manner it is found that one inch along B C represents 0.218 cu. ft. on the crank-end.

The Logarithmic Diagram

Now the indicator cards are placed on logarithmic cross-sectioned paper. On this paper there is an uneven scale. Instead of laying off the numbers, the logarithms

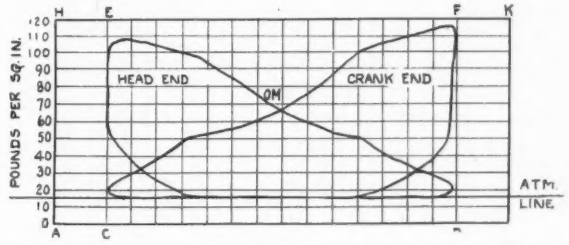


FIG. 1. AVERAGE INDICATOR CARD. SCALE OF SPRING, 60 LB., R.P.M., 291

of the numbers are laid off. To make a logarithmic cross-sectioned paper the divisions on a slide rule may be copied; or the logarithms can be looked up in a table and laid off to a convenient scale. The paper can also be purchased properly cross-sectioned.

The problem now is to draw the indicator cards on the logarithmic cross-sectioned paper. The procedure is as follows. Assume the point M on the head-end card, Fig. 1. It is 2.04 in. from the line A H and since one inch represents 0.2245 cu. ft., the cylinder volume, when the piston is at the point in its stroke represented by M, is 0.2245 × 2.04 = 0.457 cu. ft. The pressure is 75 lb. Locating this pressure and volume on the logarithmic cross-sectioned paper gives point M′, Fig. 2. Plotting other points, the head-end indicator card on the logarithmic cross-sectioned paper is obtained (Fig. 2). To avoid confusion, the crank-end is not shown; but it is obtained in an exactly similar manner.

Figure 2 is shown to help in determining how much steam and water is present in the cylinder at cutoff. From the ordinary indicator cards (Fig. 1) the volume of steam in the cylinder at cutoff can be found, but not the weight of steam as the quality of the steam is not known. From Fig. 2 the quality can be determined in the following manner. A quantity, n, known as the slope of expansion line R S, is found by drawing P W and W T, then P W ÷ W T is the slope of the line R S. In this case it is one. For the crank-end it was found to be 0.985; the average, n, is therefore 0.99.

Mr. Clayton in his experiments found the relation between this quantity n and the quality at cutoff x_c to be given by the equation

$$x_c = 1.245\ n - 0.576$$

The quality at cutoff for the case under discussion is therefore

$$x_c = 1.245 \times 0.99 - 0.576 = 0.657$$

It is now necessary to determine the volume of steam at cutoff. The head end of the cylinder contains 0.375 cu. ft. at cutoff and the crank end of the cylinder contains 0.342 cu. ft. at cutoff, making a total of 0.717 cu. ft. The average cutoff pressure is 93 lb. absolute. From the Marks and Davis steam tables the specific volume of saturated steam at 93 lb. is 4.74 cu. ft. Since the steam in the cylinder is 65.7 per cent dry, a pound of

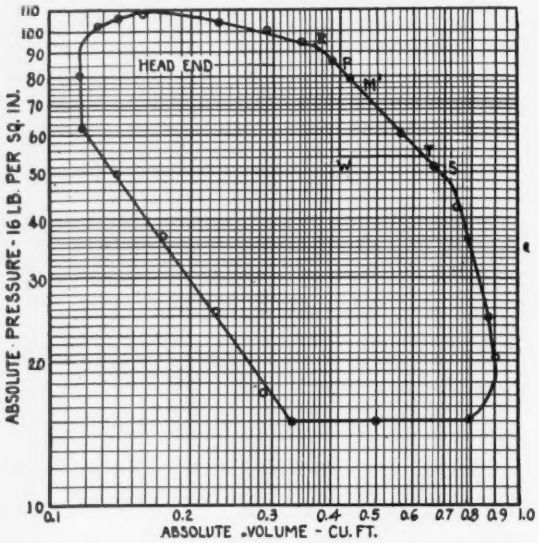


FIG. 2. HEAD END CARD OF FIG. 1 DRAWN ON LOGARITHMIC PAPER

this mixture will occupy $4.74 \times 0.657 = 3.12$ cu. ft. Since the volume of the head end and the crank end together at cutoff is 0.717 cu. ft., the weight of steam (mixture of steam and water) per revolution present at cutoff is $0.717 \div 3.12 = 0.2295$ lb.

The next step is to determine the weight of steam in the compression space. The quality of this steam is assumed as one. For a head-end compression volume of 0.3 cu. ft. the pressure is 17 lb. per sq. in. absolute. For a crank-end compression volume of 0.3 cu. ft. the pressure is 17.5 lb. per sq. in. abs. Hence for a total volume of 0.6 cu. ft. the average pressure is 17.25 lb. per sq. in. abs. From the Marks and Davis steam tables the volume of dry saturated steam for a pressure of 1725 lb. per sq. in. abs. is 23.1 cu. ft. Therefore the total weight of steam in the compression space per revolution is $0.6 \div 23.1 = 0.0259$ cu. ft. This steam is present in the amount accounted for at cutoff so that the net steam passing through the cylinder per revolution is $0.2295 - 0.0259 = 0.2036$ lb.

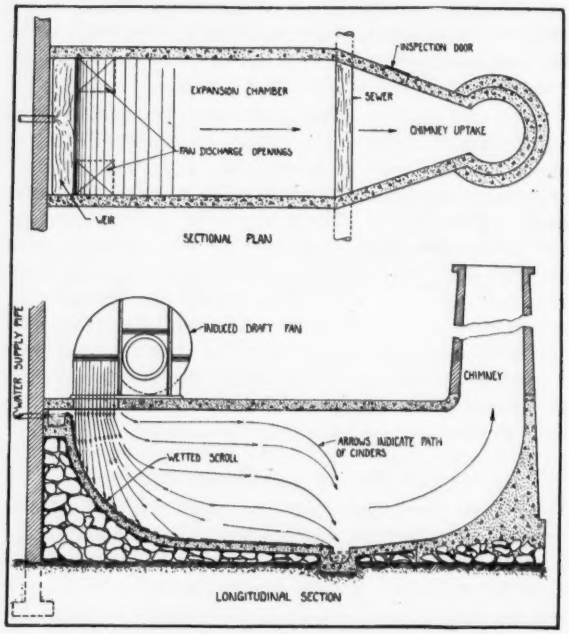
The indicated horsepower is found to be 99. The steam consumption of the engine is therefore

$$\frac{0.2036 \times 291 \times 60}{99} = 35.9 \text{ lb. per i.hp.-hr.}$$

This method of obtaining the water rate of a steam engine is relatively simple and inexpensive. It can be accomplished without interruption in operation of the plant. The accuracy obtained by the author is approximately 5 per cent. The method is limited to non-jacketed engines exhausting at approximately atmospheric pressure. It is necessary to exercise great care in obtaining the indicator cards and the engine must be in fairly good condition as to leakage.

Elimination of Chimney Dust

AT THE Lincoln plant of the Parker-Young Co., Lincoln, N. H., there has been installed a chimney gas scrubber of unusual and effective design. The operation of this scrubber, which is designated as the Schumaker Smoke Scrubber, has proven entirely satisfactory for the elimination of cinder and unburned coal under the exacting conditions imposed by the manufacture of paper.



SCRUBBER EFFECTIVELY REMOVES DUST FROM CHIMNEY GASES

Waste gases are drawn from the boilers by induced draft fans which discharge downward, causing the gases to strike and follow a curved surface or scroll over which water is constantly flowing.

Momentum of the dust particles causes many of them to strike this curved surface and be washed away to an open trench sewer which runs through the chamber connecting the fan outlets and the base of the stack.

This connecting chamber is considerably larger in cross-sectional area than either the fan outlets or the stack. As the gases leave the fan they expand with a resultant loss in velocity. The dust particles that were not eliminated by striking the washed surface will then gradually drop out, due to the low gas velocity, and be washed away to the sewer.

This scrubber will not prove effective for the elimination of black smoke, which is purely a question of furnace design and operation; it will, however, effectively wash the gases of the dust which is present and discharged from chimneys that are being operated without smoke.

This construction requires only the short stack common to induced draft installations.

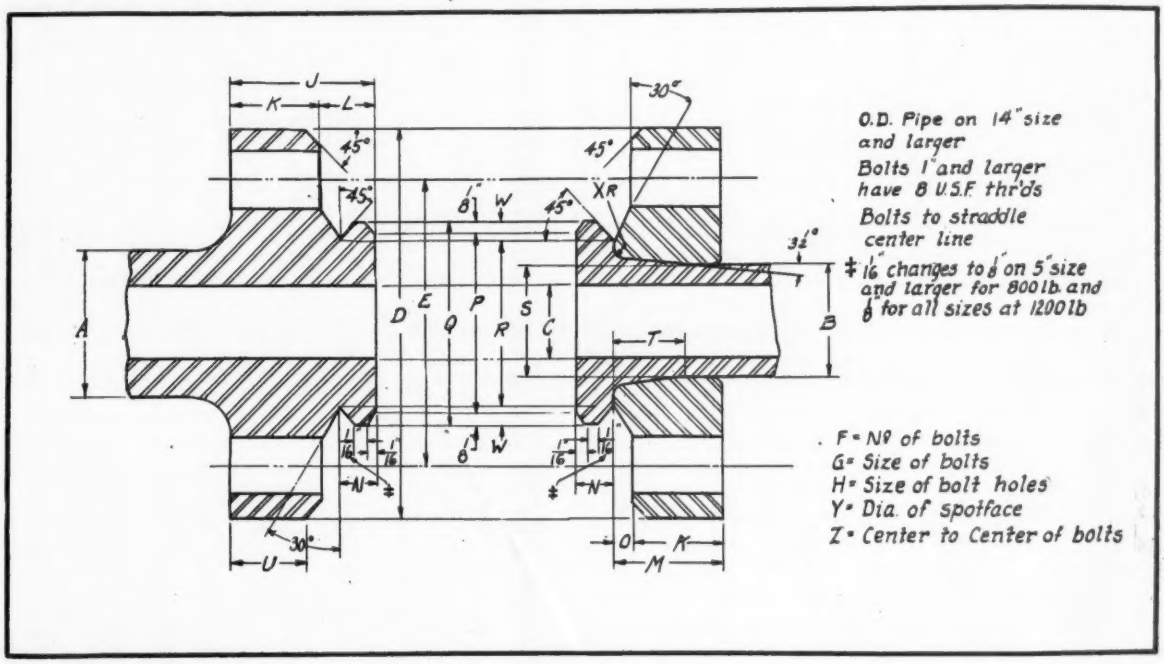
Standards for the Sargol Flanged Joint

RECOMMENDATIONS BY OLAF E. OLESON* FOR STANDARDIZATION OF FLANGES AND BOLTING FOR STEAM PRESSURES FROM 250 TO 1200 LB.

STANDARDS for the manufacture of high pressure steam valves and fittings are important not only to avoid confusion among those engineers who must specify this equipment, but also in order that stores may not be required, and now some engineers are working on still another standard for 1200 lb. steam pressure.

To bring all these various standards down to a practical number, it is recommended that the present Ameri-

TABLE I. DIMENSION TABLE RECOMMENDED FOR AMERICAN EXTRA HEAVY 400-LB. PRESSURE STANDARD, SARGOL JOINT


O.D. Pipe on 14" size and larger
Bolts 1" and larger have 8 U.S.F. thr'ds
Bolts to straddle center line
‡ 1/16" changes to 8" on 5" size and larger for 800 lb. and 8" for all sizes at 1200 lb
F = No of bolts
G = Size of bolts
H = Size of bolt holes
Y = Dia. of spotface
Z = Center to Center of bolts

Pipe Size	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z	Pipe Size
½	1 1/16	27/32	9/16	3 1/2	2 1/4	4	7/16	1/2	1 1/8	3/4	3/8	15/16	3/16	3/16	1 1/2	1 3/4	1 5/8	55/64	5/8	1/2	1/16	1/8	1 3/8	1.94	½
¾	1 5/8	1 1/16	¾	4	2 7/8	4	7/16	1/2	1 1/8	¾	3/8	15/16	3/16	3/16	1 3/4	2	1 7/8	1 5/64	5/8	9/16	1/16	1/8	1 3/8	2.03	¾
1	1 19/32	1 5/16	31/32	4 1/2	3 1/4	4	1/2	5/8	1 1/4	15/16	7/16	1 1/16	3/16	1/4	2	2 1/4	2 1/8	1 21/64	¾	5/8	1/16	1/8	1 5/8	2.29	1
1 1/4	2 1/32	1 21/32	1 9/32	5	3 3/4	4	1/2	5/8	1 5/16	7/8	7/16	1 1/8	3/16	1/4	2 3/8	2 5/8	2 1/2	1 43/64	¾	11/16	1/16	1/8	1 5/8	2.63	1 1/4
1 1/2	2 3/8	1 29/32	1 1/2	6	4 1/2	4	5/8	¾	1 1/2	1	1/2	1 1/4	1/4	1/4	2 3/4	3	2 3/4	1 59/64	7/8	¾	1/8	1/8	1 3/4	3.18	1 1/2
2	2 5/8	2 3/8	1 13/16	6 3/4	5	4	¾	7/8	1 5/8	1 1/16	1/2	1 3/8	1/4	1/4	3 1/4	3 1/2	3 1/4	2 25/64	1	13/16	1/8	1/8	2	3.53	2
2 1/2	3 5/16	2 7/8	2 5/16	7 3/4	5 7/8	4	7/8	1	1 3/4	1 1/4	1/2	1 1/2	1/4	1/4	3 7/8	4 1/8	3 7/8	2 57/64	1	15/16	1/8	3/16	2 3/8	4.15	2 1/2
3	4 1/16	3 1/2	2 13/16	8 1/4	6 5/8	8	¾	7/8	2 1/16	1 7/16	5/8	1 3/4	5/16	5/16	4 5/8	4 7/8	4 1/2	3 33/64	1 1/8	1 3/16	3/16	3/16	2	2.53	3
3 1/2	4 5/8	4	3 3/8	9	7 1/4	8	¾	7/8	2 1/8	1 1/2	5/8	1 5/8	5/16	5/16	5 1/4	5 1/2	5 1/8	4 1/64	1 3/16	1 3/16	3/16	3/16	2	2.77	3 1/2
4	5 1/16	4 1/2	3 7/16	10	7 7/8	8	7/8	1	2 1/4	1 5/8	5/8	1 5/8	5/16	5/16	5 3/4	6	5 5/8	4 33/64	1 1/4	1 1/16	3/16	3/16	2 3/8	3.02	4
4 1/2	5 9/16	5	4 5/16	10 1/2	8 1/2	8	7/8	1	2 7/16	1 13/16	¾	2 1/16	3/8	3/8	6 3/8	6 5/8	6 1/8	5 1/64	1 3/8	1 5/16	1/4	3/16	2 3/8	3.25	4 1/2
5	6 3/16	5 9/16	4 7/16	11 1/2	9 1/4	8	1	1 1/16	2 1/2	1 3/4	¾	2 1/16	3/8	3/8	7	7 1/4	6 3/4	5 37/64	1 7/16	1 5/16	1/4	3/16	2 3/4	3.54	5
6	7 1/4	6 5/8	5 3/4	12 1/2	10 5/8	12	7/8	1	2 3/4	1 7/8	7/8	2 5/16	7/16	7/16	8 3/4	8 5/8	8	6 41/64	1 9/16	1 7/16	5/16	1/4	2 3/8	2.76	6
7	8 1/4	7 5/8	6 5/8	14	11 7/8	12	1	1 1/16	2 5/16	2	15/16	2 7/16	1/2	7/16	9 5/8	9 7/8	9 1/8	7 41/64	1 5/8	1 1/2	3/8	1/4	2 3/4	3.08	7
8	9 3/8	8 5/8	7 5/8	15 3/4	13	12	1 1/16	1 1/4	3 1/16	2 1/16	15/16	2 9/16	1/2	7/16	10 5/8	10 7/8	10 1/8	8 41/64	1 3/4	1 5/8	3/8	1/4	3	3.36	8
10	11 3/4	10 3/4	9 3/4	17 1/2	15 1/4	16	1 1/8	1 1/4	3 5/16	2 1/4	15/16	2 9/16	1/2	7/16	12 7/8	13 1/8	12 3/8	10 43/64	1 7/8	1 7/8	3/8	3/8	3	2.98	10
12	14	12 3/4	11 3/4	20 1/2	17 3/4	16	1 1/4	1 3/8	3 7/16	2 1/2	15/16	2 9/16	1/2	7/16	15 1/4	15 1/2	14 3/4	12 49/64	2	1 15/16	3/8	3/8	3 1/8	3.46	12
14	15 1/4	14	12 7/8	23	20 1/4	20	1 1/4	1 3/8	3 5/16	2 7/8	1 1/16	3 3/8	9/16	1/2	16 7/8	17 1/8	16 1/4	14 1/64	2 1/4	2 5/16	7/16	3/8	3 1/8	3.17	14
15	16 1/4	15	13 7/8	24 1/2	21 1/2	20	1 1/4	1 3/8	4 1/16	3	1 1/16	3 1/2	9/16	1/2	18	18 1/4	17 3/8	15 1/64	2 3/8	2 5/16	7/16	3/8	3 1/8	3.37	15
16	17 1/4	16	14 3/4	25 1/2	22 1/2	20	1 5/8	1 1/2	4 3/8	3 1/8	1 1/4	3 3/4	5/8	5/8	19 1/8	19 3/8	18 3/8	16 1/64	2 1/2	2 1/2	1/2	3/8	3 1/4	3.52	16
18	19 1/2	18	16 3/4	28	24 3/4	24	1 5/8	1 1/2	4 1/2	3 1/4	1 1/4	3 7/8	5/8	5/8	21 1/4	21 1/2	20 1/2	18 1/64	2 5/8	2 1/2	1/2	3/8	3 1/4	3.23	18
20	21 3/4	20	18 3/4	30 1/2	27	24	1 1/2	1 5/8	4 3/4	3 1/2	1 1/4	4 1/8	5/8	5/8	23 3/8	23 5/8	22 5/8	20 1/64	2 3/4	2 9/16	1/2	3/8	4 1/4	3.53	20
22	23 5/8	22	20 1/2	33	29 1/4	24	1 5/8	1 3/4	5	3 3/4	1 1/4	4 5/8	5/8	5/8	25 1/2	25 3/4	24 3/4	22 1/64	2 7/8	2 7/8	1/2	1/2	4 1/2	3.82	22
24	25 3/4	24	22 1/2	36	32	24	1 3/4	1 7/8	5 1/4	4	1 1/4	4 5/8	5/8	5/8	27 3/4	28	27	24 1/64	3 1/8	3 1/16	1/2	1/2	4 3/4	4.17	24

too great and that manufacturers may eliminate special equipment and patterns and thus reduce the cost to the ultimate user.

Many engineers now have standards for 300 and 350 lb., others for 400 lb., and still others for 500 lb. Recently an additional standard for 600 lb. has been

can Standard for extra heavy drilling be extended up to and including 500 lb. as far as drilling and number of bolts are concerned, but that the flange diameter and thickness, and size of bolts, be calculated to withstand the various working pressures with a satisfactory factor of safety. This standard for flanges should be known as the American Extra Heavy Standard, as heretofore,

*President, The Edward Valve & Mfg. Co.

TABLE II. DIMENSION TABLE RECOMMENDED FOR AMERICAN EXTRA HEAVY 500-LB. PRESSURE STANDARD, SARGOL JOINT

Pipe Size	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z	Pipe Size
½	1 1/16	27/32	9/16	3 1/2	2 1/4	4	7/16	1/2	1 1/8	3/4	3/8	15/16	3/16	3/16	1 1/2	1 3/4	1 5/8	55/64	5/8	1/2	1/16	1/8	1 3/8	1.94	½
¾	1 3/8	1 1/16	¾	4	2 7/8	4	7/16	1/2	1 1/8	¾	3/8	15/16	3/16	3/16	1 3/4	2	1 7/8	1 5/64	5/8	9/16	1/16	1/8	1 3/8	2.03	¾
1	1 19/32	1 5/16	31/32	4 1/2	3 1/4	4	1/2	5/8	1 1/4	15/16	3/16	1 1/16	3/16	1/4	2	2 1/4	2 1/8	1 21/64	¾	5/8	1/16	1/8	1 5/8	2.29	1
1 1/4	2 1/32	1 21/32	1 9/32	5 1/4	3 3/4	4	5/8	¾	1 7/16	1	7/16	1 1/4	3/16	1/4	2 3/8	2 5/8	2 1/2	1 43/64	7/8	¾	1/16	1/8	1 3/4	2.63	1 1/4
1 1/2	2 3/8	1 29/32	1 1/2	6 1/4	4 1/2	4	¾	7/8	1 3/4	1 1/4	1/2	1 1/2	1/4	1/4	2 3/4	3	2 3/4	1 59/64	1	15/16	1/8	1/8	2	3.18	1 1/2
2	2 5/8	2 3/8	1 15/16	7	5	4	7/8	1	1 15/16	1 5/16	1/2	1 9/16	1/4	1/4	3 1/4	3 1/2	3 1/4	2 25/64	1	15/16	1/8	1/8	2 3/8	3.53	2
2 1/2	3 5/16	2 7/8	2 5/16	7 3/4	5 7/8	4	7/8	1	1 7/8	1 3/8	1/2	1 5/8	1/4	1/4	3 7/8	4 1/8	3 7/8	2 57/64	1 1/16	1 1/16	1/8	3/16	2 3/8	4.15	2 1/2
3	4 1/16	3 1/2	2 5/16	8 1/4	6 5/8	8	¾	7/8	2 1/16	1 7/16	5/8	1 3/4	5/16	5/16	4 5/8	4 7/8	4 1/2	3 33/64	1 1/8	1 1/16	3/16	3/16	2	2.53	3
3 1/2	4 5/8	4	3 3/8	9	7 1/4	8	¾	7/8	2 1/8	1 1/2	5/8	1 5/16	5/16	5/16	5 1/4	5 1/2	5 1/8	4 1/64	1 3/16	1 1/16	3/16	3/16	2	2.77	3 1/2
4	5 1/16	4 1/2	3 9/16	10	7 7/8	8	7/8	1	2 1/4	1 5/8	5/8	1 5/16	5/16	5/16	5 3/4	6	5 5/8	4 33/64	1 1/4	1 1/16	3/16	3/16	2 3/8	3.02	4
4 1/2	5 5/16	5	4 5/16	10 1/2	8 1/2	8	7/8	1	2 7/16	1 11/16	¾	2 1/16	3/8	3/8	6 3/8	6 5/8	6 1/8	5 1/64	1 3/8	1 5/16	1/4	3/16	2 3/8	3.25	4 1/2
5	6 5/16	5 5/16	4 13/16	11 1/2	9 1/4	8	1	1 1/8	2 1/2	1 3/4	¾	2 1/8	3/8	3/8	7	7 1/4	6 3/4	5 37/64	1 7/16	1 5/16	1/4	3/16	2 3/4	3.54	5
6	7 3/8	6 5/8	5 3/4	12 3/4	10 5/8	12	7/8	1	2 3/4	1 7/8	7/8	2 5/16	7/16	7/16	8 3/8	8 5/8	8	6 41/64	1 9/16	1 7/16	5/16	1/4	2 3/8	2.76	6
7	8 1/2	7 5/8	6 5/8	14	11 7/8	12	1	1 1/8	2 5/16	2	15/16	2 7/16	1/2	7/16	9 5/8	9 7/8	9 1/8	7 41/64	1 5/8	1 5/8	3/8	1/4	2 3/4	3.08	7
8	9 5/8	8 5/8	7 5/8	15 1/2	13	12	1 1/8	1 1/4	3 1/16	2 1/8	15/16	2 9/16	1/2	7/16	10 5/8	10 7/8	10 1/8	8 41/64	1 3/4	1 5/8	3/8	1/4	3	3.36	8
10	12 1/16	10 3/4	9 3/4	17 3/4	15 1/4	16	1 1/4	1 3/8	3 3/16	2 1/4	15/16	2 9/16	1/2	7/16	12 7/8	13 1/8	12 3/8	10 49/64	1 7/8	1 5/16	3/8	3/8	3 1/16	2.98	10
12	14 3/8	12 3/4	11 3/4	20 1/2	17 3/4	16	1 3/8	1 1/2	3 7/16	2 1/2	15/16	2 5/16	1/2	7/16	15 1/4	15 1/2	14 3/4	12 49/64	2	2	3/8	3/8	3 1/4	3.46	12
14	15 5/8	14	12 7/8	23	20 1/4	20	1 1/4	1 3/8	3 5/16	2 7/8	1 1/16	3 3/8	9/16	1/2	16 7/8	17 1/8	16 1/4	14 64	2 1/4	2 5/16	3/8	3/8	3 1/8	3.17	14
15	16 5/8	15	13 3/4	24 1/2	21 1/2	20	1 3/8	1 1/2	4 1/16	3	1 1/16	3 1/2	9/16	1/2	18	18 1/4	17 3/8	15 1/64	2 3/8	2 3/8	7/16	3/8	3 1/4	3.37	15
16	17 1/2	16	14 1/2	25 1/2	22 1/2	20	1 1/2	1 5/8	4 1/2	3 1/4	1 1/4	3 7/8	5/8	5/8	19 1/8	19 3/8	18 3/8	16 1/64	2 5/8	2 7/16	1/2	3/8	4 1/4	3.52	16
18	19 3/4	18	16 1/2	28	24 3/4	24	1 1/2	1 5/8	4 3/4	3 1/2	1 1/4	4 1/8	5/8	5/8	21 1/4	21 1/2	20 1/2	18 1/64	2 3/4	2 5/8	1/2	3/8	4 1/4	3.23	18
20	22	20	18 1/2	30 1/2	27	24	1 5/8	1 3/4	4 7/8	3 5/8	1 1/4	4 1/4	5/8	5/8	23 3/8	23 5/8	22 5/8	20 1/64	2 7/8	2 7/8	1/2	3/8	4 1/2	3.53	20
22	23 3/4	22	20	33	29 1/4	24	1 3/4	1 7/8	5 3/8	3 7/8	1 1/2	4 3/8	¾	¾	25 3/4	26	24 3/4	22 1/64	3	3 1/16	5/8	1/2	4 3/4	3.81	22
24	26	24	22	36	32	24	1 7/8	2	5 5/8	4 1/8	1 1/2	4 5/8	¾	¾	28	28 1/4	27	24 1/64	3 1/8	3 1/4	5/8	1/2	5	4.18	24

TABLE III. DIMENSION TABLE RECOMMENDED FOR AMERICAN DOUBLE EXTRA HEAVY 600-LB. PRESSURE STANDARD, SARGOL JOINT

Pipe Size	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z	Pipe Size
½	1 5/16	27/32	9/16	4 1/4	3	4	1/2	5/8	1 1/4	7/8	3/8	1 1/16	3/16	3/16	1 3/8	1 5/8	1 1/2	55/64	¾	11/16	1/16	1/8	1 5/8	2.12	½
¾	1 1/2	1 1/16	¾	4 3/4	3 3/8	4	1/2	5/8	1 3/8	1	3/8	1 3/16	3/16	3/16	1 3/4	2	1 7/8	1 5/64	13/16	¾	1/16	1/8	1 5/8	2.38	¾
1	1 27/32	1 5/16	31/32	5 1/2	4	4	5/8	¾	1 1/2	1 1/8	3/8	1 5/16	3/16	3/16	2	2 1/4	2 1/8	1 21/64	7/8	7/8	1/16	1/8	1 3/4	2.83	1
1 1/4	2 3/32	1 21/32	1 3/32	6	4 3/8	4	5/8	¾	1 11/16	1 1/4	7/16	1 1/2	1/4	1/4	2 3/8	2 5/8	2 1/2	1 43/64	1	15/16	1/16	1/8	1 3/4	3.09	1 1/4
1 1/2	2 1/2	1 29/32	1 1/2	6 3/4	4 7/8	4	¾	7/8	1 7/8	1 3/8	1/2	1 5/8	1/4	1/4	2 3/4	3	2 3/4	1 59/64	1 1/8	1	1/8	1/8	2	3.44	1 1/2
2	3 1/16	2 3/8	1 15/16	7 1/2	5 7/8	8	5/8	¾	2	1 1/2	1/2	1 3/4	1/4	1/4	3 1/4	3 1/2	3 1/4	2 25/64	1 3/16	1 3/16	1/8	1/8	2	2.25	2
2 1/2	3 9/16	2 7/8	2 5/16	8 1/2	6 1/2	8	¾	7/8	2 1/4	1 3/4	1/2	2	1/4	1/4	3 7/8	4 1/8	3 7/8	2 57/64	1 5/16	1 5/16	1/8	3/16	2	2.48	2 1/2
3	4 5/16	3 1/2	2 5/16	9 1/2	7 1/2	8	7/8	1	2 1/2	1 7/8	5/8	2 3/16	5/16	5/16	4 5/8	4 7/8	4 1/2	3 33/64	1 7/16	1 1/2	3/16	3/16	2 3/8	2.87	3
3 1/2	4 7/8	4	3 3/8	10 3/4	8 1/2	8	1	1 1/8	2 3/4	2	5/8	2 7/16	5/16	5/16	5 1/4	5 1/2	5 1/8	4 1/64	1 5/8	1 1/2	3/16	3/16	2 3/4	3.25	3 1/2
4	5 5/16	4 1/2	3 5/16	11 1/2	9 1/4	8	1 1/8	1 1/4	3	2 3/8	5/8	2 9/16	5/16	5/16	5 7/8	6 1/8	5 3/4	4 33/64	1 11/16	2	3/16	3/16	3	3.54	4
4 1/2	6 5/16	5	4 5/16	13	10 1/2	8	1 1/8	1 1/4	3 1/4	2 1/2	¾	2 7/8	3/8	3/8	6 1/2	6 3/4	6 1/4	5 1/64	1 15/16	2	1/4	3/16	3	4.01	4 1/2
5	6 1/16	5 5/16	4 1/16	14	11 1/2	8	1 1/8	1 1/4	3 5/16	2 3/4	1 3/16	3 5/16	5/8	9/16	7 1/4	7 1/2	7	5 37/64	2 1/4	2 1/4	1/4	3/16	3	4.40	5
6	7	6 5/8	4 29/32	15	12 1/2	12	1 1/8	1 1/4	4 3/8	3	1 3/8	3 5/8	¾	5/8	8 5/8	8 7/8	8 1/4	6 41/64	2 7/16	2 1/2	5/16	1/4	3	3.23	6
7	8 1/8	7 5/8	5 7/8	16 1/2	13 3/4	12	1 1/4	1 3/8	4 3/4	3 1/4	1 1/2	3 7/8	7/8	5/8	9 7/8	10 1/8	9 1/2	7 41/64	2 9/16	2 5/16	5/16	1/4	3 1/16	3.56	7
8	9 3/8	8 5/8	6 7/8	18 1/2	15 1/2	12	1 3/8	1 1/2	5	3 1/2	1 1/2	4 1/8	7/8	5/8	11 1/8	11 3/8	10 5/8	8 41/64	2 3/4	2 7/8	3/8	1/4	3 1/4	4.01	8
10	12	10 3/4	9	21 1/2	18 1/2	16	1 3/8	1 1/2	5 1/4	3 3/4	1 1/2	4 3/8	7/8	5/8	13 1/2	13 3/4	12 7/8	10 49/64	2 15/16	3 1/8	7/16	3/8	3 3/4	3.60	10
12	14 3/8	12 3/4	11	24	21	20	1 3/8	1 1/2	5 1/2	4	1 1/2	4 5/8	7/8	5/8	15 1/2	15 3/4	14 7/8	12 49/64	3 1/16	3 3/8	7/16	3/8	3 1/4	3.28	12
14	15 5/8	14	12	25 1/4	22	20	1 1/2	1 5/8	5 3/4	4 1/4	1 1/2	4 7/8	7/8	5/8	17	17 1/4	16 1/4	14 1/64	3 1/4	3 9/16	1/2	3/8	4 1/4	3.44	14
15	16 3/4	15	13	27 1/4	23 3/4	20	1 5/8	1 3/4	5 7/8	4 3/8	1 1/2	5	7/8	5/8	18	18 1/4	17 1/4	15 1/64	3 5/16	3 5/8	1/2	3/8	4 1/2	3.71	15
16	18	16	14	27 3/4	24 1/4	20	1 3/4	1 7/8	6	4 1/2	1 1/2	5 1/8	7/8	5/8	19	19 1/4	18 1/4	16 1/64	3 7/16	3 11/16	1/2	3/8	4 3/4	3.79	16

TABLE IV. DIMENSION TABLE RECOMMENDED FOR AMERICAN DOUBLE EXTRA HEAVY 800-LB. PRESSURE STANDARD, SARGOL JOINT

Pipe Size	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z	Pipe Size
½	1 5/16	27/32	9/16	4 1/4	3	4	1/2	5/8	1 3/8	1	3/8	1 3/16	3/16	3/16	1 1/2	1 3/4	1 5/8	55/64	13/16	11/16	1/16	1/8	1 5/8	2.12	½
¾	1 5/8	1 1/16	¾	4 3/4	3 3/8	4	5/8	¾	1 1/2	1 1/8	3/8	1 5/16	3/16	3/16	1 7/8	2 1/8	2	1 5/64	7/8	15/16	1/16	1/8	1 3/4	2.38	¾
1	2 1/32	1 5/16	31/32	5 1/2	4	4	5/8	¾	1 5/8	1 1/4	3/8	1 7/16	3/16	3/16	2 1/8	2 3/8	2 1/4	1 21/64	1	1	1/16	1/8	1 3/4	2.83	1
1 1/4	2 3/32	1 21/32	1 3/32	6	4 3/8	4	¾	7/8	1 13/16	1 3/8	7/16	1 5/8	3/16	1/4	2 1/2	2 3/4	2 5/8	1 43/64	1 1/8	1 1/8	1/16	1/8	2	3.09	1 1/4
1 1/2	2 3/4	1 29/32	1 1/2	6 3/4	4 7/8	4	7/8	1	2	1 1/2	1/2	1 3/4	1/4	1/4	2 7/8	3 1/8	2 7/8	1 59/64	1 3/16	1 3/16	1/8	1/8	2 3/8	3.44	1 1/2
2	3 5/16	2 3/8	1 15/16	7 1/2	5 7/8	8	¾	7/8	2 1/8	1 5/8	1/2	1 7/8	1/4	1/4	3 3/8	3 5/8	3 3/8	2 25/64	1 1/4	1 3/8	1/8	1/8	2	2.25	2
2 1/2	3 15/16	2 7/8	2 5/16	8 1/2	6 1/2	8	7/8	1	2 3/8	1 7/8	1/2	2 1/8	1/4	1/4	4	4 1/4	4	2 57/64	1 7/16	1 1/2	1/8	3/16	2 3/8	2.48	2 1/2
3	4 9/16	3 1/2	2 5/16	9 1/2	7 1/2	8	7/8	1	2 5/8	2	5/8	2 5/16	5/16	5/16	4 3/4	5	4 5/8	3 33/64	1 9/16	1 11/16	3/16	3/16	2 3/8	2.87	3
3 1/2	5 1/8	4	3 3/8	10 3/4	8 1/2	8	1	1 1/8	2 3/4	2 1/8	5/8	2 7/16	5/16	5/16	5 1/4	5 1/2	5 1/8	4 1/64	1 5/8	1 11/16	3/16	3/16	2 3/4	3.25	3 1/2
4	5 5/16	4 1/2	3 5/16	11 1/2	9 1/4	8	1 1/8	1 1/4	3	2 3/8	5/8	2 9/16	5/16	5/16	5 7/8	6 1/8	5 3/4	4 33/64	1 11/16	2	3/16	3/16	3	3.54	4
4 1/2	6 5/16	5	4 5/16	13	10 1/2	8	1 1/8	1 1/4	3 1/4	2 1/2	¾	2 7/8	3/8	3/8	6 1/2	6 3/4	6 1/4	5 1/64	1 15/16	2	1/4	3/16	3	4.01	4 1/2
5	6 1/16	5 5/16	4 1/16	14	11 1/2	8	1 1/8	1 1/4	3 5/16	2 3/4	1 3/16	3 5/16	5/8	9/16	7 1/4	7 1/2	7	5 37/64	2 1/4	2 1/4	1/4	3/16	3	4.40	5
6	7	6 5/8	4 29/32	15	12 1/2	12	1 1/8	1 1/4	4 3/8	3	1 3/8	3 5/8	¾	5/8	8 5/8	8 7/8	8 1/4	6 41/64	2 7/16	2 1/2	5/16	1/4	3	3.23	6
7	8 1/8	7 5/8	5 7/8	16 1/2	13 3/4	12	1 1/4	1 3/8	4 3/4	3 1/4	1 1/2	3 7/8	7/8	5/8	9 7/8	10 1/8	9 1/2	7 41/64	2 9/16	2 11/16	5/16	1/4	3 1/16	3.56	7
8	9 3/8	8 5/8	6 7/8	18 1/2	15 1/2	12	1 3/8	1 1/2	5	3 1/2	1 1/2	4 1/8	7/8	5/8	11 1/8	11 3/8	10 5/8	8 41/64	2 3/4	2 7/8	3/8	1/4	3 1/4	4.01	8
10	12	10 3/4	9	21 1/2	18 1/2	16	1 3/8	1 1/2	5 1/4	3 3/4	1 1/2	4 3/8	7/8	5/8	13 1/2	13 3/4	12 7/8	10 49/64	2 15/16	3 1/8	7/16	3/8	3 3/4	3.60	10
12	14 3/8	12 3/4	11	24	21	20	1 3/8	1 1/2	5 1/2	4	1 1/2	4 5/8	7/8	5/8	15 1/2	15 3/4	14 7/8	12 49/64	3 1/16	3 3/8	7/16	3/8	3 1/4	3.28	12
14	15 5/8	14	12	25 1/4	22	20	1 1/2	1 5/8	5 3/4	4 1/4	1 1/2	4 7/8	7/8	5/8	17	17 1/4	16 1/4	14 1/64	3 1/4	3 9/16	1/2	3/8	4 1/4	3.44	14
15	16 3/4	15	13	27 1/4	23 3/4	20	1 5/8	1 3/4	5 7/8	4 3/8	1 1/2	5	7/8	5/8	18	18 1/4	17 1/4	15 1/64	3 5/16	3 5/8	1/2	3/8	4 1/2	3.71	15
16	18	16	14	27 3/4	24 1/4	20	1 3/4	1 7/8	6	4 1/2	1 1/2	5 1/8	7/8	5/8	19	19 1/4	18 1/4	16 1/64	3 7/16	3 11/16	1/2	3/8	4 3/4	3.79	16

TABLE V. DIMENSION TABLE RECOMMENDED FOR AMERICAN DOUBLE EXTRA HEAVY 1200-LB. PRESSURE STANDARD, SARGOL JOINT

Pipe Size	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z	Pipe Size
½	1	27/32	¼	4¼	3	4	½	5/8	1 9/16	1⅛	7/16	1 5/16	¼	3/16	1 5/8	1⅞	1¾	55/64	⅞	15/16	1/16	⅛	1 5/8	2.12	½
¾	1 5/16	1 1/16	5/16	4¾	3⅜	4	5/8	¾	1 11/16	1¼	7/16	1 7/16	¼	3/16	2	2¼	2⅛	1 5/64	1	1 1/16	1/16	⅛	1 3/4	2.38	¾
4	1 5/8	1 5/16	19/32	5½	4	4	5/8	¾	1 5/16	1⅜	9/16	1 5/8	5/16	¼	2¼	2½	2¼	1 21/64	1 1/16	1 1/8	1/16	⅛	1 3/4	2.83	1
1¼	2	1 21/32	29/32	6	4⅜	4	¾	⅞	2 1/16	1½	9/16	1 3/4	5/16	¼	2 5/8	2⅞	2⅝	1 43/64	1 3/16	1 1/4	1/8	⅛	2	3.09	1¼
1½	2 3/8	1 29/32	1 3/32	6¾	4⅞	4	⅞	1	2 5/16	1 5/8	11/16	1 15/16	3/8	5/16	3	3¼	3	1 59/64	1 5/16	1 5/16	1/8	⅛	2 3/8	3.44	1½
2	3	2 3/8	1½	7½	5⅞	8	¾	⅞	2 9/16	1⅞	11/16	2 3/16	3/8	5/16	3½	3¾	3½	2 25/64	1 7/16	1 5/8	1/8	⅛	2	2.25	2
2½	3⅜	2⅞	1 25/32	8½	6½	8	⅞	1	2 15/16	2	15/16	2 7/16	½	7/16	4⅛	4⅜	4	2 57/64	1 5/8	1 5/8	3/16	3/16	2 3/8	2.48	2½
3	4 1/16	3½	2 5/16	9½	7½	8	⅞	1	3 1/16	2⅛	15/16	2 9/16	½	7/16	4⅞	5⅛	4¾	3 33/64	1 3/4	1 3/4	3/16	3/16	2 3/8	2.87	3
3½	4 5/8	4	2 23/32	10¾	8½	8	1	1⅛	3 9/16	2⅜	1 3/16	2 15/16	5/8	9/16	5½	5¾	5¼	4 1/64	1 5/16	1 5/16	1/4	3/16	2 3/4	3.25	3½
4	5 3/16	4½	3 5/32	11¾	9¼	8	1⅛	1¼	3 3/16	2 5/8	1 3/16	3 3/16	5/8	9/16	6	6¼	5¾	4 33/64	2 1/8	2 1/8	1/4	3/16	3	3.54	4
4½	5 3/4	5	3 19/32	13¼	10½	8	1¼	1 3/8	4 1/16	2⅞	1 3/16	3 7/16	5/8	9/16	6 5/8	6 7/8	6 3/8	5 1/64	2 5/16	2 5/16	1/4	3/16	3 1/8	4.01	4½
5	6 5/16	5 9/16	4 1/16	14¼	11½	8	1¼	1 3/8	4¼	3	1¼	3 5/8	5/8	5/8	7¼	7½	7	5 37/64	2 3/8	2 7/16	1/4	3/16	3 1/8	4.40	5
6	7½	6 5/8	4 29/32	15¼	12½	12	1¼	1 3/8	4 5/8	3¼	1 3/8	3 7/8	¾	5/8	8 5/8	8 7/8	8¼	6 41/64	2 9/16	2 9/16	5/16	¼	3 1/8	3.23	6
7	8 7/8	7 5/8	5 7/8	16¾	13¾	12	1 3/8	1½	4 7/8	3 3/8	1½	4	⅞	5/8	9 7/8	10 1/8	9½	7 41/64	2 5/8	2 3/4	5/16	¼	3 1/4	3.56	7
8	10 1/4	8 5/8	6 7/8	18¾	15½	12	1½	1 5/8	5	3½	1½	4 1/8	⅞	5/8	11 1/8	11 3/8	10 5/8	8 41/64	2¾	2 13/16	3/8	¼	4 1/4	4.01	8
10	12 3/4	10 3/4	8¾	22	18½	16	1½	1 5/8	5 3/8	3⅞	1½	4½	⅞	5/8	13½	13¾	12⅞	10 49/64	3	3 1/16	7/16	3/8	4 1/4	3.60	10
12	15 1/4	12 3/4	10¾	24½	21	20	1 5/8	1¾	5 3/4	4¼	1½	4 7/8	⅞	5/8	15½	15¾	14⅞	12 49/64	3¼	3½	7/16	3/8	4½	3.28	12

except that the pressures be designated in connection with it.

It is further recommended that the present 1200 lb. Hydraulic Standard be adopted for pressures ranging above 500 lb. up to 1200 lb., inclusive, as far as drilling circle diameter and number of bolts are concerned, and that the flange diameter and thickness and size of bolts be calculated to provide for a satisfactory factor of safety under various pressures from 500 to 1200 lb., inclusive. This standard should be the American Double Extra Heavy Standard with pressure designated.

These recommendations contemplate the use of not more than two standards for pressures from 250 lb. to 1200 lb., inclusive, in steam service. This gives due consideration to the specifying engineer, the plant operator and the manufacturer; in fact, the operator is really given preference because he is the one who maintains and lives with the installation of valves and fittings for the life of the material. With but two standards for high pressure material, the plant operator could more readily make repairs or renewals in his high-pressure piping with a small stock on hand, this being impossible under present conditions with the number of standards now in use.

In recommending two high pressure standards in connection with flanges and bolting, attention has been given to the important factor of locating the bolt circle as close to the fitting or pipe wall as possible, which tends to eliminate to a great extent the unequal temperature between the bolting and the piping proper. Further, this would minimize the unequal stress or distortion of the flanges and bolting at times of heating and cooling. The necessary fillets in castings between flanges and fittings or valve necks must be taken into consideration, not only from the viewpoint of strength and safety, but from a manufacturing and construction standpoint as well. The bolt circle must be of sufficient diameter to facilitate the erection of the valve or fitting without the use of a special wrench and should permit the use of a standard nut on the bolt without machining away the entire fillet on the casting.

Some engineers and manufacturers think that there should be but one standard for bolt circle and number of bolts up to and including 1200 lb., and that the American Extra Heavy Standard should be used for the purpose. It is a fact that this is theory only and not at all practicable because it does not allow for a proper factor of safety. It is obvious that for the higher pressures an increased metal thickness in the necks of valves and fittings must be used. This would not be the case in the same degree if forged steel were used for this purpose, but since the valves and fitting must be made of cast steel it is necessary to provide for an increased factor of safety because even in the best steel casting practice blow-holes and segregation of metal may be encountered. The consequent increased diameter of the neck then requires an increased diameter of bolt circle in order to provide for space in which to turn the nut without spot-facing the entire fillet from the casting. It is clearly shown by the foregoing that the use of the American Extra Heavy bolt circle would not provide ample space between the bolts and the wall nor between adjacent bolts if used for pressures above 500 lb.

Dimensional data given herewith shows the Sargol flange in detail for the several pressures considered. While the proposed Double Extra Heavy drilling circle, which is comparable to the present 1200 lb. hydraulic standard, is somewhat too large for 600 lb., it is the smallest that can be used for 1200 lb., and in order to get down to two standards it was necessary to find a workable mean that would be both safe and practicable. For pressures up to and including 500 lb. the American Extra Heavy drilling circle and number of bolts is also workable and satisfactory from the standpoint of the engineer, manufacturer and operator.

EXPERIMENTAL WORK performed by Dr. Reinhardt Thiessen, associate chemist of the Department of the Interior, at the Pittsburgh experiment station of the Bureau of Mines, shows that it is possible to differentiate and identify the Pittsburgh, Redstone and Sewickley coal beds by microscopic examination. The Pittsburgh bed can readily be recognized by the large amount of small crinkly spores, which comprise about 95 per cent of the spores present. In the Redstone bed none of the characteristic Pittsburgh bed spores is found except in rare cases, when a very few are present. In the Sewickley bed are found some of the characteristic crinkly appearing Pittsburgh bed spores, but not very many.

Construction of Stacks and Flues*

RECENT BOILER PLANT DESIGN HAS BEEN ACCOMPANIED BY PRACTICAL CHANGES IN STACK AND FLUE CONSTRUCTION

FOR THE purpose of a construction comparison, stacks may be considered under four separate headings, namely: steel, either guyed or self-supporting; radial or common brick; reinforced concrete, and a combination of tile and reinforced concrete.

Steel stacks are usually lined for their full length with 4½ in. of second grade fire brick, this may be varied, however, by substituting common brick for the upper portion. It is customary to support this lining on steel shelf angles, spaced about 20 ft. apart. A space of 1 to 1½ in. left between the stack and the lining may be filled with grout, this offers excellent protection

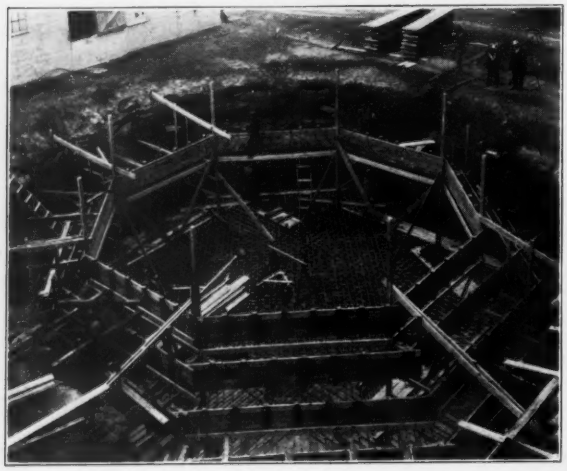


FIG. 1. FORM WORK AND PLACEMENT OF REINFORCEMENT FOR STACK FOUNDATION FOR THE OHIO PUBLIC SERVICE CO., LORAIN, O.

against acid attack on the steel. A cast-iron coping placed on top of the stack will prevent rain from seeping into and behind the lining.

External corrosion of metal stacks may be prevented by periodic painting, this is of particular importance in warm climates near the sea. To facilitate painting it is general practice to provide a top runway with trolley, the support of which must be well drained to prevent rapid corrosion. Lightning protection should be provided for steel stacks resting on masonry foundations, however, no protection need be provided for steel stacks superimposed on the structural steel of the building.

BRICK STACKS

Common brick stacks construction has been almost entirely superseded by the use of radial brick. The cement joints are generally relied upon for locking the brick, although in some cases reinforcing steel rods have been laid between the units to give additional circumferential strength. Brick stacks are sometimes unlined, however it is the general practice to line them for about 50 ft. above the flue opening with either second quality fire brick or common brick. The lining, in any event, should be independent of the stack shell and it may rest upon a concrete floor installed below the flue opening or it may be carried down to the stack foundation.

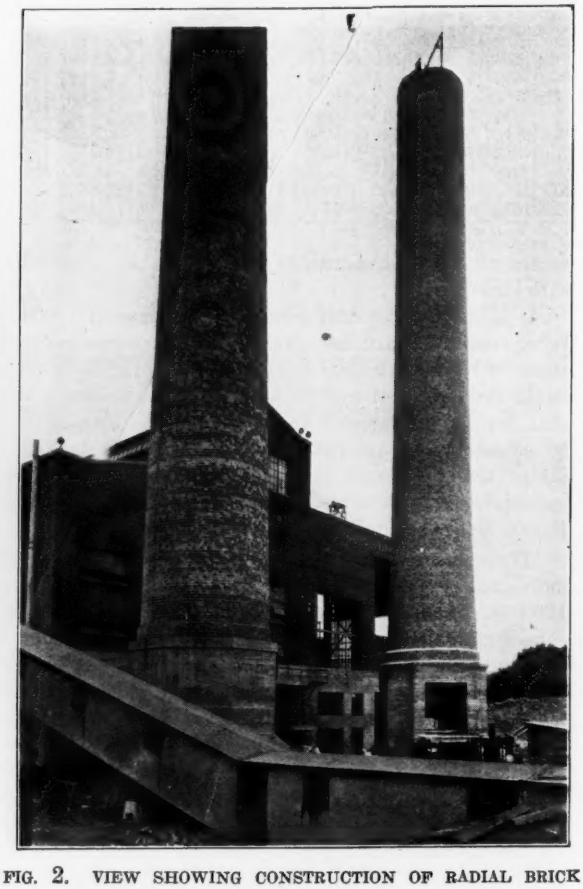


FIG. 2. VIEW SHOWING CONSTRUCTION OF RADIAL BRICK STACK ON FOUNDATION SHOWN IN FIG. 1.

Cast-iron copings are commonly provided to protect the stack and lining from the weather. Lightning protection must be provided, this to consist of three or more platinum tipped copper points connected by a heavy copper cable to a ground plate which should be permanently buried in moist soil.

CONCRETE STACKS

Concrete stacks have not been in general use long enough to establish definitely their reliability and permanence. The human element in mixing and placing concrete must be carefully watched and it is suggested that specifications should require at least 2 in. of dense aggregate outside of any reinforcement. It is also suggested that a surface hardening wash be used in place of the usual outside cement wash finish.

Cast-iron coping or a hard cement finish may be used to finish off the stack at the top and suitable lightning protection should be provided. Concrete stacks may be lined in the same manner as brick stacks.

*Abstract from the 1923 Report of the Prime Movers Committee, N. E. L. A.

Combination stacks consisting of an inner and an outer shell of special shaped tile have been constructed. Reinforced concrete is used to fill the space between the two shells. This construction offers many of the best features of both brick and concrete stacks.

General Construction Notes

Where two flues enter a stack from opposite sides is metal or firebrick baffle should be provided to prevent loss of draft, this baffle is set to change the direction of gas flow to the vertical.

Outside ladders are always desirable. Insurance rules require inclosing rings and it is a good plan to

DRAFT REQUIREMENTS AT MAXIMUM RATING

	Minimum Inches of Water	Maximum Inches of Water
1. Furnace draft, with forced draft under stokers (For stokers not equipped with forced draft figures are 0.20 to 0.40)	0.05	0.10
2. Setting losses or loss through boiler	0.35	0.80
3. Uptake losses	0.05	0.25
4. Economizer losses	0.30	5.00
5. Cinder catchers	0.25	0.45
6. Flues between economizers and stack	0.10	0.25
7. Stack entrance loss	0.05	0.10
8. Stack friction loss	0.05	0.10
Total	1.15	6.95

use bronze insert anchors for the double purpose of eliminating the danger due to corrosion and to avoid unsightly rust streaks on the face of the stack.

Rapid development in size, design, and operation of steam boilers have made necessary accurate methods of stack proportioning. The variables which affect stack proportioning may be summarized as follows: (1) fuel to be burned, (2) forced or natural air supply to grate, (3) boiler ratings anticipated, (4) furnace volume, (5) arrangement of heating surface, (6) installation of economizer and (7) allowable gas velocities through the stack.

Masonry flues have been almost entirely superseded by the use of steel plate construction which lends itself readily to proportioning the various flue areas so that the gas velocity remains about constant or varies slowly from the value at the damper to that at the base of the stack.

Clearance must be provided around all dampers for distortion of the same, and expansion joints must be provided in long flue runs and at the connection to the stack. The inside insulation of flues is theoretically correct in that it protects the flue metal from high temperatures, however, insulation used as a flue cover will give longer service and will be easily and economically accessible for maintenance.

Clean-out doors should be provided at various points. An expansion joint which is giving satisfaction is of the combined slip and bellows type, the sliding portion of the joint preserves alinement and the bellows portion provides for the expansion and at the same time makes the joint air tight.

There is a definite trend toward outdoor construction for all voltages above 6600 v. in substations located where conditions are such that outdoor construction is feasible. Such construction is much cheaper and has been developed to such an extent as to be practically as durable and free from trouble as the indoor type.

Determining Carbon Monoxide Poisoning

A METHOD known as the pyro-tannic acid method for the quantitative determination of carbon monoxide in blood and air is described in Serial 2486, just issued by the Department of the Interior, through the Bureau of Mines. In the treatment of any illness the early diagnosis is of very great importance. This is especially true in cases of carbon monoxide poisoning, whether acute or sub-acute in character. A diagnosis of carbon monoxide poisoning is usually made from a correlation of the history, the possible place of exposure, and the symptoms produced. This, however, is not positive evidence because carbon monoxide often is present in unsuspected places and can be absent in suspected places. Also, the symptoms of this type of poisoning are common to other causes. In many cases, the correct diagnosis may be very difficult, if not impossible by this method and as a result little or no treatment is given. Sub-acute cases, those in which the subject is exposed to concentration sufficient to cause only headaches, malaise, feeling of weakness and dizziness, may be incorrectly diagnosed and as a result, improperly treated. Probably the best method of diagnosis is by examination of the subject's blood. Many methods for the detection of carbon monoxide in the blood have been developed, but owing to their various individual disadvantages have never come into common usage. Some of the quantitative methods are satisfactory with regard to accuracy but require elaborate and expensive apparatus, special technique and training, or are too delicate and cumbersome for field use.

It is of vital importance in all industrial and domestic accidents occurring at places where carbon monoxide might be suspected or where the symptoms are typical of carbon monoxide poisoning that a qualitative and preferably a quantitative determination be made (the extent of poisoning being of importance in deciding whether carbon monoxide was the direct or contributary cause) to show the presence or absence of carbon monoxide.

In view of these facts, an apparatus has been designed by technologists of the Department of the Interior, Bureau of Mines, which gives accurate results in the field and laboratory, yet it is compact and durable, and sufficiently simple in operation to be used without special training. By use of the method described in Serial 2486, it is possible to detect the presence of carbon monoxide in the blood in 3 min. and to determine the exact amount present within 15 min. and on the basis of these findings, treatment may be administered. The method and apparatus should fulfill the needs of hospitals, industrial surgeons, safety engineers, coroners, departments of public safety, boards of health, and other allied organizations.

In Chicago the cold storage industry is taking its first step toward central station distribution of cold storage. The Fulton and Market streets cold storage plants, in which were installed during 1910 two 600-horse-power synchronous motors driving ice machines, will furnish refrigeration for several other large warehouses which are going up in the vicinity.

Practical Construction of Alignment Charts*

THEIR PURPOSE, METHODS OF USE, AND AN OUTLINE OF METHOD OF CONSTRUCTION. BY R. T. LIVINGSTON†

IN ENGINEERING work it is often necessary to repeat one type of calculation a large number of times. To reduce the amount of labor involved and to reduce the time of making such calculation it is common practice to make a "calculation chart" for performing the necessary computations. These charts are usually in one of two forms: first, those which consist of a family of straight or curved lines radiating from a number of points, laid out on rectangular cross section paper, by means of which various calculations may

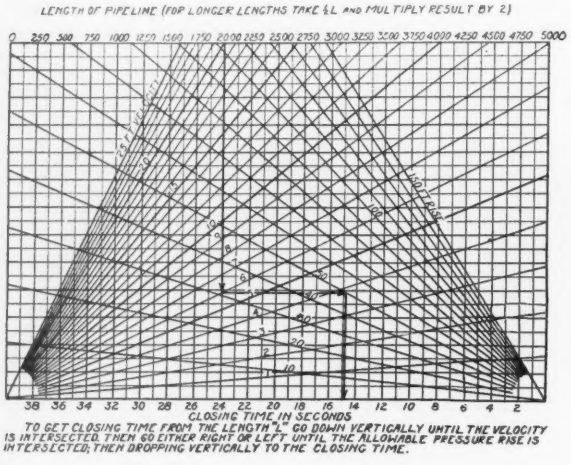

LENGTH OF PIPE LINE (FOR LONGER LENGTHS TAKE ½L AND MULTIPLY RESULT BY 2)
0 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 4750 5000
VELOCITY
PRESSURE RISE
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2
CLOSING TIME IN SECONDS
TO GET CLOSING TIME FROM THE LENGTH "L" GO DOWN VERTICALLY UNTIL THE VELOCITY IS INTERSECTED; THEN GO EITHER RIGHT OR LEFT UNTIL THE ALLOWABLE PRESSURE RISE IS INTERSECTED; THEN DROPPING VERTICALLY TO THE CLOSING TIME.

FIG. 1. PRESSURE RISE CHART

be made, and second, the "monograph" or "alinement" charts, which consist of three or more parallel lines, on which are laid off the desired factors to some scale, usually a logarithmic scale. Multiplication or division is performed by connecting points on two scales with a straightedge and reading the intersections on the third line.

As a general rule, it may be said that the alinement chart is easier to read and to use, there being less chance of error and interpolation usually being unnecessary. These charts may be made to solve any formula, but for practical considerations their use is almost always confined to formulas which have nothing but multiplication, division, and powers of numbers. Addition and subtraction (as will be shown later), while not being impossible, often make the solution of the formula by this form of chart as difficult or more difficult than it would be without it; hence, in the following article only the construction of simple charts will be explained, the construction of one more complex formula being outlined to show the difficulties which would be encountered.

For the purpose of illustrating the comparison between the two types of charts, two formulas are shown, worked out by each method. Figures 1 and 2 illustrate two "family of line" charts, the former being a "pressure rise chart" and the latter a "flywheel effect chart."

Figures 3 and 4 illustrate these same two formulas in the form of alinement charts.

These two charts are for the solution of problems in speed regulation of hydraulic turbines, the formula for the first one being the approximate formula for the pressure rise in penstocks due to closure of turbine gates.

Here $t = \frac{2.L.V.}{g.h.}$ where "L" is the length of the pipe line in feet, "V" the velocity in ft/sec, "g" equals the gravitational constant and "h" the allowable pressure

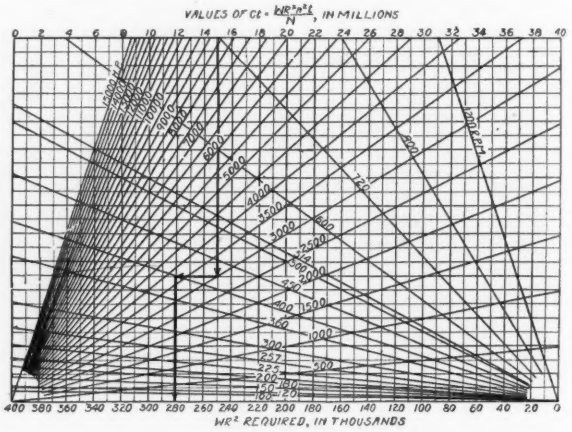


FIG. 2. FLYWHEEL EFFECT CHART

rise in feet. This gives "t" the time of closure in seconds. The formula for the second chart is $C = \frac{WR^2.n^2}{H.P.}$ where C is a constant of regulation used in Marks' Handbook, WR^2 is the flywheel effect in ft.-lb. squared, n is the number of r.p.m. and hp. is the full load hp. The greater neatness, clarity and ease of use of alinement charts is immediately apparent by the comparison between these two. Referring to Fig. 3, the method of using an alinement chart is as follows: join the desired point on scale A with the point on scale B and read intersection on scale S. Through this point on scale S draw a line through the given point on scale Y. Extend this line to intersect scale Z and the reading on scale Z at the point of intersection is the answer. Thus in the example shown by the dotted line in Fig. 3, if we have given a 1000-ft. pipe line in which the water flows with a velocity of 8 ft. per sec. and it is desired to see what closing time we would get with an allowed pressure rise of 50 ft., connect 1000 on scale A with 8 on scale B and read 795 on scale S. Connect this point with 50 ft. on scale Y and read 10 sec. on scale Z. This is the answer. Further, we can easily try the effect of different pressure rises. Of course the length of the pipe line and the velocity in the line are constant for any fixed conditions, hence the intersection on scale S will remain the same. If we allowed a 100-ft. pressure rise, the closing time could be reduced to 5 sec., and if

* All rights reserved by the author.
† Hydro-Mechanical Engineer, New York City.

we only allowed a 25-ft. pressure rise the closing time would be increased to 20 sec.

In a similar manner, in Fig. 4, it can be seen that with 1000 hp. at 225 r.p.m. for an assumed value of C equals 4.5 million we will need a W.R.^{2} of 90,000. This factor C is the same as the factor K given on page 1096 of Marks' Mechanical Engineers' Handbook and the table given there is reproduced here so as to show the per cent of change in speed given for different values of C.

Approx. Speed Reg. in Open Flume Turbines

C in Millions	Reg. time of Gov.								
	1 sec.			1½ sec.			2 sec.		
	PER CENT LOAD CHANGE								
	100	50	25	100	50	25	100	50	25
5	16	7.5	4.5	24	11	7.0	32	15	9.0
6	14	6.5	4.0	21	10	6.0	28	13	8.0
7	12	5.5	3.5	18	8	5.0	24	11	7.0
8	10	4.5	3.0	15	7	4.3	20	9	6.0
9	9	4.0	2.5	13.5	6	4.0	18	8	5.0
10	8	3.5	2.3	12	5.5	3.5	16	7	4.5

While the usual method of calculating alinement charts is not difficult nor particularly complicated for the trained mathematician or engineer who knows his mathematics thoroughly, the procedure nevertheless seems very abstruse to the ordinary man. In the various books, should the readers be interested, can be found mathematical methods of calculating these charts together with the theory upon which they are based. (See Lipka and Pettie on Construction of Mathematical Charts.)

In order to use these methods, however, it is necessary that the theory of logarithms be thoroughly understood and while most engineers and draftsmen use logarithms and slide rules daily and doubtless at one time master their theory, nevertheless having understood them and learned how to work with them, have forgotten the theory and use them without any further thought. Hence any of these methods demand that logarithms be reviewed and learned again, and most men do not wish that extra work.

Alinement charts may be found in a great variety of forms, depending to a great extent upon the whim of the designer. The commonest forms are a series of straight parallel lines with logarithmic scales, but in many cases a simple decimal scale is used and in some cases the lines form a "Z" or are curved or sloped. Such charts are, however, only special cases and to consider them here would only tend to confuse the reader, hence the construction of charts consisting of straight parallel lines upon which are marked logarithmic scales only will be treated in this article.

In the procedure given herewith, no attempt has been made to show the theory; but a method is given whereby anyone who can use a slide rule and logarithms and who knows the elements of drafting can construct charts sufficiently accurate for almost any work. The accuracy depends entirely upon the care taken in preparation of the chart; that is to say, the exactness of the calculations and of the drafting.

The following materials will be required:

1. Some good transparent tracing cloth.
2. Hard pencil, sandpaper block and eraser.
3. Logarithmic cross section paper (three sheets each size).
4. Table of logarithms.
5. Slide rule.
6. T square and triangles.

Instead of drawing on regular drawing paper, the author has found that tracing cloth is best. From the

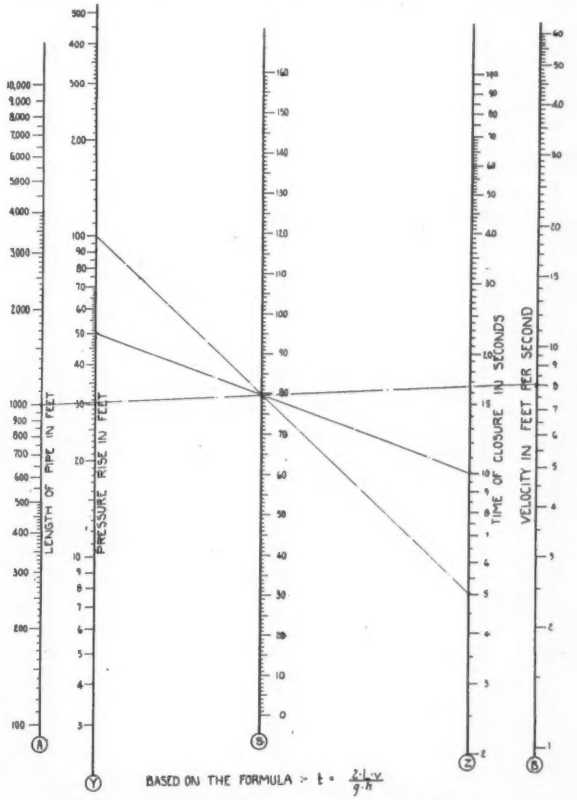


FIG. 3. PRESSURE RISE CHART, ALINEMENT TYPE

description of the method which follows, the reason for this is obvious. Cut a piece of tracing cloth slightly greater than the desired size of the chart. If extreme accuracy is required, the author has found that it is best to make the chart approximately four times as large as required; that is to say, double all dimensions and the photostat down to size; but if no photostat machine is available. then extreme care must be taken in preparation of the chart. The use of a hard pencil with a wedge point is recommended and the point should be kept sharp as possible to obtain the best intersections.

From any manufacturer of draftsman supplies secure a complete set of all the different sizes of logarithmic cross section paper which they manufacture, at least three sheets of each size. The author has eight different sizes of logarithm paper and at least 10 scales of miscellaneous sizes which he had made as circumstances demanded. Cut one piece of each size into strips and paste these strips carefully together, so that the 10 mark on one strip connects with the one mark on the next. This must be done very accurately or there will be errors in the divisions of the scale. Not only must

they be pasted together accurately as to the vertical scale, but the strip must be even vertically; that is to say, the horizontal lines must coincide. These strips should be from ¾ in. to 1 in. wide in order to give them sufficient strength.

At any desired point near the left-hand side of the drawing board, draw a long vertical line of approximately the length desired for the chart. Now beneath this line on the tracing paper push one of the strips, the choice of strips depending upon the range of the first factor. This strip should be held down securely

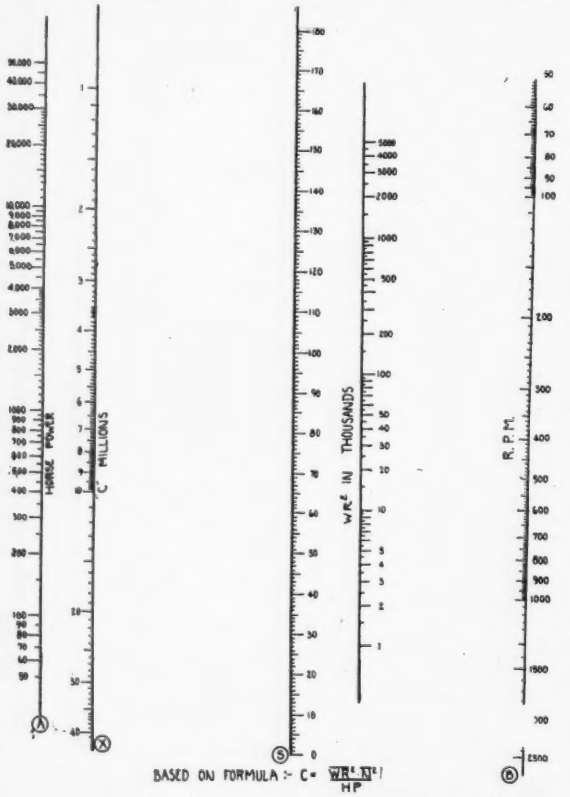


FIG. 4. ALINEMENT CHART FOR DETERMINING FLYWHEEL EFFECT

at top and bottom. It is suggested that the main divisions be marked and labeled. The author has found it a good idea to mark the strips 1, 2, 3, 4, etc., and then add the ciphers as requisite upon the tracing cloth. Now on the tracing paper at some other convenient point, where it is desired to have the outside right-hand line, draw another perpendicular line for the other factor. Proceed as before as to scale, etc. If the second factor is to multiply the first, the scales should run the same way, thus 1-10-100, etc. If the second factor is to divide, however, the second scale should run in the opposite direction to the first; that is to say, 100-10-1, etc. This will bring the answer line, or "support" as it is commonly called, between the two lines previously drawn.

To determine the support line, a number of points must be calculated; at least two, better three. Now, in order to determine a point, it is necessary to have two intersecting lines and still better three. If a straight multiplication chart is desired where the formula $A \cdot B = S$ is to be solved, several points on S should be determined. For example, if we desire to locate 10, 100, 1000, then 2×5, 4×2.5 and 5×2 would determine 10 and three other products would likewise determine 100 and 1000. Then draw straight lines in pencil connecting these points; thus 2 on scale A with 5 on scale B and 4 on the scale A with 2.5 on scale B, etc. If the construction is accurate (and it must be), these three lines will intersect in a point and this point is the 10 point on the support line. In a similar manner, the 100 and the 1000 points may be determined and all these three points must lie on the same straight line, which straight line must be parallel to the A and B lines.

It is at this point that the advantage of the tracing cloth becomes apparent. If for any reason the location or length of the support line is not as desired, the location can be shifted by shifting the location of one of the two "factor" lines, and the length can be changed by changing the scale of one of the two factors. Having tracing cloth, it is convenient to shift position or scale and still leave the original work and thus see whether the changes made were of advantage or not. If the scales taken on the two factor lines are the same and the powers of both factors are unity, then the support line would be half way between the two and the scale on the support line would be half as long as on the original. If a constant multiplies the two factors, then the scale on the support is merely shifted up or down the support and if either of the factors is raised to any power, the effect is to shift the support line in one direction or the other. The exact amount of change due to these causes cannot be given in an article of this sort and experience only will show. The next article in this series will thoroughly explain, in all steps, the construction of the usual form of chart and the third or last article will illustrate various types of charts and show in general how special formulas may be attacked for the simplest solution. It must be remembered, however, that all the author hopes to do is to guide the reader and that practice alone will make him expert in the solution of such charts.

Synchronous Motors for Ammonia Compressors

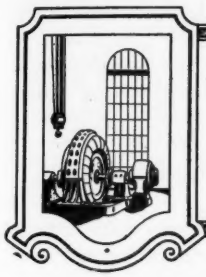
IN THE ordinary application of synchronous motors to air compressors and pumps, when starting unloaded, motor starting is generally a simple operation. The problem of applying synchronous motors to ammonia compressors is, in general, more difficult than to air compressors for several reasons:

Many ammonia compressors run at slower speed and therefore require large flywheels.

The larger the flywheel the greater will be the starting torque required to accelerate the compressor, and the large flywheel also makes it more difficult to obtain the necessary pull-in torque.

Ammonia compressors cannot therefore be unloaded to the atmosphere, therefore a bypass is necessary. If this is not large enough, the power required to force the gas through the pipes while bringing the compressor up to speed may be excessive.

It is more difficult to build slower-speed synchronous motors for high starting and pull-in torque than to build high speed machines.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Direct Current Control

PART II. METHODS OF SPEED REGULATION AND THEIR APPLICATION. BY GORDON FOX

RESISTORS for use with controllers have been classified as being adapted for light or heavy starting duty and intermittent or continuous speed regulating duty. A resistor having a given continuous rating in amperes capacity, may be given a higher capacity rating if the service is intermittent and a still higher rating if used for starting duty. The ratings laid down by Electric Power Club are based on a temperature rise not to exceed 250 deg. C. under the stated conditions of service. The service corresponding to the classifications given are as follows:

LIGHT STARTING DUTY resistors are designed to be in circuit not to exceed 15 sec. out of every 4 min. with capacity load.

HEAVY STARTING DUTY resistors are designed to be in circuit not to exceed 30 sec. out of every 4 min.

SPEED REGULATION LIGHT INTERMITTENT DUTY resistors are designed to be in circuit 1 min. out of every 4 min.

SPEED REGULATION HEAVY INTERMITTENT DUTY resistors are designed to be in circuit 2 min. out of every 4 min.

SPEED REGULATION CONTINUOUS DUTY resistors are designed to be in circuit continuously.

Table II, which appeared in the first part of this article and which is reproduced here for convenience, shows the Electric Power Club classification of resistors. Designating numbers are given the various resistor combinations according to the total resistance and duty classification. Thus a class 74 resistor for a motor of stated horsepower at stated voltage will be designed to pass full load current on the first point. This resistor may be used for speed regulation service if it is not in circuit to exceed 2 min. out of each 4 min. It may also be used for starting duty, but will be heavier than necessary for this service. The number of steps may be specified, otherwise the resistor will be sub-divided by the manufacturer to suit the controller with which it is to be used.

This rather elaborate classification of resistors is desirable from the manufacturer's viewpoint. It tends, however, to a multiplicity of designs and a lack of standardization and duplication if resistors of all classes are used. It is the author's recommendation that the user select and standardize, as far as possible, one or two classes of resistors which are sufficiently heavy to meet his general requirements, such, for instance, as class 35 for starting duty and class 95 for speed control duty. The slight increase in first cost which may accrue from this practice is ordinarily warranted through advantages of interchangeability and duplication. The standardization of resistors has been carried still further in some large plants, to the extent of employing a few standard resistor units and connecting them variously to obtain required ohms and capacity. This a highly commendable practice.

Percent of Full Load Current on First Point	Starting Torque in Percent of Full Load Torque				Resistor Class Number				
					Starting Duty		Speed Regulating Duty		
							Intermittent		
	Series Motor	Compound Motor, 30% Series	Shunt Motor	Wound Rotor Induction Motor	Light 15 Sec. in 4 Min.	Heavy, 30 Sec. in 4 Min.	Light 1 Min. in 4 Min.	Heavy 2 Min. in 4 Min.	Continuous
25	8	12	25	.....	11	31	51	71	91
50	30	40	50	30	12	32	52	72	92
70	50	60	70	50	13	33	53	73	93
100	100	100	100	100	14	34	54	74	94
150	170	160	150	150	15	35	55	75	95
200	250	230	200	200	16	36	56	76	96

TABLE II. ELECTRIC POWER CLUB SERVICE CLASSIFICATION OF ACCELERATING RESISTORS

Accelerating resistors are usually so connected that they are all in circuit on the first step. The resistance is then reduced by short circuiting the individual steps in sequence. In some cases, however, only a portion of the resistor is in circuit on the first step. The resistance is then reduced by cutting in additional resistors in parallel. In the first case, the dissipating ability is reduced as the resistor is cut. In the second case, the dissipating ability is increased as additional resistors are cut in to bring the motor up to speed.

TO CONTROL THE SPEED OF ROTATION

Speed of rotation of a direct current motor depends upon the fact that the motor endeavors to maintain definite relations between impressed armature volts and counter-volts. It is possible to govern the motor speed either by controlling the impressed armature volts or by adjusting the field strength to affect the counter-volts. The various methods of speed control may be briefly reviewed at this point.

ARMATURE VOLTAGE METHODS

MULTI-VOLTAGE SYSTEM—If circuits of different voltages are available, the armature may be supplied from

more than one voltage. Other conditions being equal, the speed will be proportional to the impressed voltage. This is termed the multi-voltage system. It is not in extensive use.

VARIABLE VOLTAGE SYSTEM—The voltage of the generator supplying the motor armature may be varied. The motor speed will vary directly with the generator voltage, other conditions being equal. This method is possible only when the armature is supplied from an individual generator. It is used for a few special applications only.

ARMATURE RESISTANCE CONTROL—The speed of a direct current motor may be reduced by decreasing the

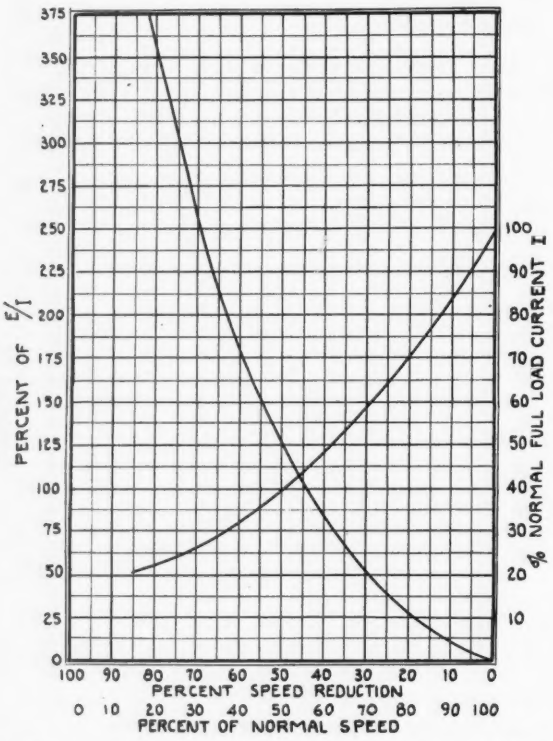


FIG. 1. CURVES FOR DESIGN OF SPEED CONTROL OF MOTOR DRIVING A FAN LOAD

voltage impressed on the armature. When the impressed voltage is reduced the counter-voltage must drop to a like degree to maintain the current at a value necessary to carry the load. Consider a shunt motor connected to a machine requiring a constant torque at all loads, corresponding to 50 amp. armature current. With full voltage impressed the motor will operate at full speed, say 1200 r.p.m. If the controller is adjusted so that 1 ohm resistance is in series with the armature, the voltage across the armature will be reduced by the amount of the drop in the resistor. This drop is equal to the resistance, 1 ohm, times the current, 50 amp., and is 50 v. The voltage at the armature terminals is $220 - 50 = 170$ v. The speed will decrease to correspond to this voltage. The speed is directly proportional to the armature voltage (with constant excitation) thus:

$$S = \frac{170}{220} \times 1200 = 927 \text{ r.p.m.}$$

If the resistance in series with the armature is increased to 2 ohms then the drop through it will be $2 \times 50 = 100$ v. The voltage at the armature terminals will be $220 - 100 = 120$ v. and the corresponding speed will be

$$S = \frac{120}{220} \times 1200 = 654 \text{ r.p.m.}$$

In the first case, the speed decreased from 1200 to 927 r.p.m., or 273 r.p.m.; in the second case, from 1200 to 654 r.p.m., a reduction of 546 r.p.m., or twice that in the first case. From this it is seen that where the torque remains constant, the speed decreases in proportion to the resistance in series with the armature.

If the torque is not constant the speed does not vary in proportion to the series resistance. At light loads, there is little drop even with comparatively high resistance. Suppose, for instance, with a certain series resistance that the load is decreased to an extent such that only 10 amp. is required to drive the motor. Then the drop through the resistance is $2 \times 10 = 20$ v., which leaves $220 - 20 = 200$ v. at the armature terminals. This will give a speed

$$S = \frac{200}{220} \times 1200 = 1091 \text{ r.p.m.}$$

From this it can be seen that this method affords little speed adjustment for light load conditions. The heavier the load, the greater the speed range available.

Two general types of load must be considered in determining the resistance to be used for speed regulating duty. The majority of drives have an approximately constant torque characteristic, and the horsepower increases with the speed. The amount of resistance to be used to obtain a given speed reduction may be determined by the formula

$$R = P \times \frac{E}{I}$$

Where R = total regulating resistance in ohms.
P = per cent speed reduction; decimal.
E = line voltage.
I = current to develop required torque.

This formula is based on the fact previously explained, namely, with a constant torque load, the reduction is proportional to the resistance.

The torque of fans, centrifugal pumps and some other machines, increases with the speed. The friction load torque is about constant, but the air or water delivery torque varies as the square of the speed and the horsepower varies approximately as the cube of the speed. In Fig. 1, curve A is a fan load characteristic, showing the relation between speed and current required. Curve B indicates the corresponding value of armature resistance necessary to secure a desired speed reduction.

Suppose it is desired to obtain 50 per cent reduction in speed on the fan in Fig. 1. At 50 per cent speed, the current is only 40 per cent of full load current. It is necessary to provide resistance sufficient to give the necessary voltage drop with this low current. The resistance in this case will be approximately

$$R = \frac{0.5E}{0.4I} - \frac{1.25\,E}{I}$$

Where R = total regulating resistance in ohms
E = line voltage
I = current taken to develop torque required at full speed.

At 25 per cent reduction in speed the current is 65 per cent of full load value and the resistance required

$$R = \frac{0.25E}{0.65I} = \frac{0.38E}{I}$$

Figure 1 may be used to determine approximately the amount of resistance necessary for any drive of "fan duty" characteristic, to give a desired speed reduction if the current I be taken as that required at full speed.

Since the current required by a "fan duty" load varies at different speeds, the current capacity of the different sections of the resistor may be proportioned accordingly. The range of speeds afforded in any case by a given amount of total armature circuit resistance may be determined by the formula

$$\text{Speed range in per cent} = \frac{T_1}{T_2} \times 100$$

Where T_1 = the actual torque demand at slowest speed, expressed in per cent of full load torque. T_2 = the peak

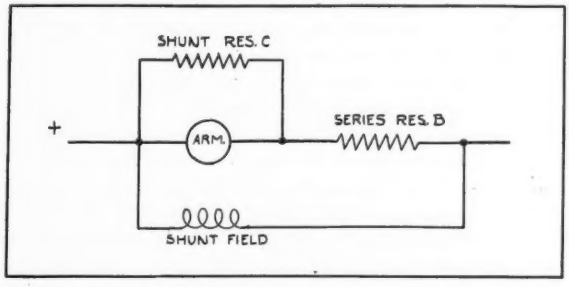


FIG. 2. SHUNT MOTOR WITH ARMATURE SERIES AND SHUNT RESISTORS

torque developed by the inrush on the first point of the controller expressed in per cent of full load torque. Thus, if a shunt motor is provided with a resistor which will permit 150 per cent full load current inrush and if the corresponding torque is 150 per cent of full load torque and if the torque demanded at slowest speed is 60 per cent of full load torque

$$\text{Speed range} = \frac{60}{150} \times 100 = 40 \text{ per cent},$$

that is, this resistance will permit of armature speed control from 60 per cent speed to full speed. If a wider range is desired, the external resistance must be increased.

Armature Shunt Resistance Control

Three limitations of speed control by resistance in series with the armature are: widely varying speeds with changing load, inability to reduce the speed with light loads and inability to secure stable low speeds. These limitations may be materially alleviated through the use of a resistor shunting the armature in addition to that in series with it. Figure 2 illustrates this arrangement. Lower and more uniform speeds are obtained by this method than by simple armature resistance control, due to the fact that the armature shunting resistor passes a current which increases the drop in the series resistor and causes a decreased voltage to be applied to the armature even when the load is light and the armature current small. A stabilizing influence is obtained because of the fact that the higher the armature voltage, the greater the current carried by the armature resistor; this current flowing through the series resistor tending to reduce the impressed armature voltage. A comparison with control by series resistance alone may be made through an example.

Consider a shunt motor having a full load current of 50 amp. at 230 v. Let resistor B = 3 ohms and resistor C = 2 ohms. If no armature shunt resistor is used, the drop across resistor B is 150 v. at full load and 15 v. when the load is 5 amp. The speed with 50-amp. load will be approximately $\frac{80}{230}$ of rated speed and at 5-amp. load it will be $\frac{215}{230}$ of rated speed. If the armature shunt is used, the calculations are as follows:

Armature current = I
Armature voltage = E_a

$$\text{Current through C} = \frac{E_a}{2}$$

$$\text{Drop across B} = 3\left(I + \frac{E_a}{2}\right)$$

$$E_a = 230 - 3\left(I + \frac{E_a}{2}\right) = \frac{2(230 - 2I)}{5}$$

Let $I = 50$ amp.
$E_a = 32$ v.

$$\text{Current through C} = \frac{E_a}{2} = 16 \text{ amp.}$$

$$\text{Current through B} = 16 + 50 = 66 \text{ amp.}$$

$$\text{Speed} = \frac{32}{230} \text{ (approx.) of rated speed.}$$

Let $I = 5$ amp.
$E_a = 86$ v.

$$\text{Current through C} = \frac{E_a}{2} = 43 \text{ amp.}$$

$$\text{Current through B} = 43 + 5 = 48 \text{ amp.}$$

$$\text{Speed} = \frac{86}{230} \text{ (approx.) of rated speed.}$$

It will be seen that the effect of the armature shunt is to reduce the speed at all loads and to make possible a considerable speed reduction even with light loads. This method of speed control is frequently applied for such installations as elevators and skip hoist where a slow speed reasonably constant for all loads, is desired for a short period when approaching a landing so that accurate stops may be made. It is also used to secure low initial speeds for starting or adjusting machinery, as for setting up a printing press or threading in a paper

calender. The method is seldom applicable for continuous duty as the losses in the resistors are apt to be prohibitive.

Series Parallel Control

Two or more motors may be supplied for driving one machine. The motors are ordinarily duplicates and are similarly connected to the machine. If the armatures of these motors be connected in parallel across the line each motor will assume a portion of the load, operating at its corresponding speed. If the two armatures be connected in series the voltage across each armature is reduced. If there is no external resistance in the armature circuit then each armature has one-half line voltage across its terminals. The result is that the required counter-voltage is halved and the motor operates at half

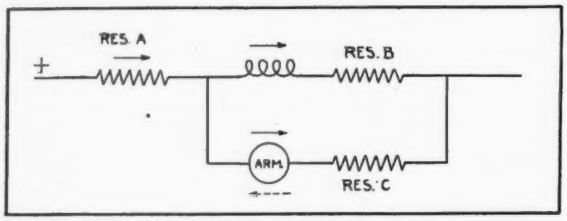


FIG. 3. LOWERING CONNECTIONS OF A TYPICAL CRANE HOIST CONTROLLER

speed. A two to one speed range is thus seen to be possible with installations where two motors, mechanically connected, may be operated with their armatures connected either in series or in parallel.

Field Strength Methods

If the field strength of a motor be changed, the counter-voltage generated at a given speed is immediately affected. Since the motor tends to maintain a balanced relation between impressed volts and counter-volts it follows that a change in field strength brings about a change in speed sufficient to re-establish the balanced condition. Weakening the field of a motor tends to reduce the counter-voltage and thus forces the motor to speed up. Strengthening the field has the opposite effect.

Shunt Field Resistance Control

Perhaps the most common field control application is the adjustable speed motor. The motor is designed to operate at its minimum rated speed with the shunt field connected across the line. The shunt field is weakened by the insertion of resistance in series with it. At any given position of the field rheostat the motor speed remains nearly constant, regardless of the load. The range of speed control depends upon the design of the motor. Almost any well designed shunt interpole motor will permit an increase of 15 to 25 per cent above normal rated speed. Adjustable speed motors are standard for ranges up to 4 to 1. In applying this method, care must be exercised to ascertain that the maximum safe speed of the driven machine is not exceeded. It is not always necessary to employ the full possible speed range of a given motor. The amount of resistance in the field rheostat can be arranged to give any range within the limits of the motor's rating.

Starting an Adjustable Speed Motor

If an adjustable speed motor be started with weakened field, the torque developed per ampere input into the armature is relatively low. As a result, the motor may be unable to start with normal current input and, in any case, the acceleration will be slow. If the accelerating resistor is cut out, either manually or by a time element controller, at the usual rate, excessive currents will flow due to the slow acceleration and the deficiency in counter-voltage developed. For the reasons above stated, an adjustable speed motor should always be started with the shunt field fully excited. Provision is made in most controllers to insure this condition.

It is very often desired to set the field rheostat of an adjustable speed motor to give a speed best suited to the work in hand. It is further desirable then to be able to start and stop the motor without the necessity of readjusting the rheostat each time. To make this possible, many controllers are arranged with a relay which functions to short circuit the field rheostat while starting and then to introduce it after the accelerating resistor is cut out. Such a controller is said to afford predetermined speed control.

Field Control With Series Motors

It is not possible to adjust the field strength of a series motor independently by means of series resistors. If a resistor be connected around the series field of a series motor it will divert from that field some of the current which it would otherwise normally carry. The effect is to weaken the field and increase the speed. This method is not extensively used, but it is sometimes employed to secure a high speed operating point in crane hoist controllers. The shunting resistor and its connecting leads must be of very low ohmic value. The armature shunt, previously mentioned in connection with shunt motors, may also be employed with series motors. If the shunting resistor is connected around the armature only, both the armature current and the shunt resistor current pass through the series field of the motor. The influence of the shunt resistor is thus two fold. It increases the series field excitation at all loads, the effect being most pronounced at light loads. It has an effect equivalent to the addition of shunt ampere turns to the field winding and tends to give the motor a compound characteristic. The use of an armature resistor with a series motor has an effect similar to that obtained with a shunt motor but in a greater degree. The heating of the series field windings due to increased current places limitations on this practice.

Series motors are commonly employed for "dynamic lowering" with crane hoist controllers. When hoisting, the motor is connected in a normal manner with the armature, series field, series brake coil and accelerating resistor all connected in series. The connections for lowering are such as practically to convert the series field into a shunt field by placing it across the line in series with resistors. Figure 3 shows the lowering connections of a typical hoist controller. The motor is operative with either a positive or negative load. If the load is positive, the motor will drive the hoist downwards and current will flow in the direction indicated by the arrows. If the weight handled is just sufficient to overcome the friction of the hoist, the load is zero, no current

flows through the armature but the field is excited. With an overhauling load, the armature current is reversed, as indicated by the dotted arrow, but the field current continues in the same direction. The speed can be controlled by varying the series field current by varying the resistors A and B in series therewith, or by changing the resistor C in series with the armature. The resistor C reduces the speed as a motor and increases the speed as a generator when the load overhauls. When operating as a motor, the counter-voltage plus the drop in resistors A and C equals line voltage; the resistors decrease the speed. When operating as a generator, the resistance drop in the armature circuit increases the counter-voltage which must be developed to cause the flow of armature current necessary to produce the required restraining torque, hence increases the speed.

Sources of Power for Three-Wire D. C. Systems

A Study of the Three Principal Methods of Supplying Three-Wire Circuits. By M. S. Hancock

INCANDESCENT lamps made for low voltages, as 125 v., are far less fragile, and are more serviceable, than those made for higher voltages, such as 250 v. Motors are equally satisfactory for either voltage. Doubling the voltage of a line, moreover, permits of using only one-fourth of the copper in the line, while still maintaining the same percentage line drop. It is evident, then, that when a large number of lamps, or a combination of motors and lamps, are to be supplied with power it is desirable to have the distribution voltage about 250 v. and the voltage across the lamps about 125 v. A three-wire system permits of doing this.

A three-wire system consists of two main lines and a neutral line together with a source of power for the lines. The full line voltage (250 v. assumed) is impressed across the main lines. The neutral line is maintained at an electrical potential about midway between the two main lines. If 250 v. is impressed between the two main lines, then the voltage from either line to the neutral is 125 v. If the load between the main lines and the neutral is kept well balanced, very little of the current is carried by the neutral line, as most of the load current simply comes from one of the main lines to the neutral, and from there goes on to the other main line. Therefore, the neutral wire may be small in section, and distribution occurs at 250 v. although only 125 v. is applied across the lamps and smaller motors.

Power may be supplied for a three-wire system in any of three different ways. A three-wire generator may be used to supply power to all of the lines; a simple generator may supply power to the two main lines, and a balancer set maintain the neutral line potential at the proper value; or two direct-current generators may be connected to the main lines, and the point of connection between the two generators connected to the neutral line. These different sources are not the only possible ones, but cover most ordinary cases.

Three-Wire Generators

Three-wire generators are the most usual source of power for three-wire systems. They may be considered as modifications of standard two-wire generators. Two slip rings are connected to certain conductors of the armature of a two-wire generator, which are so selected that when one is connected to a bar under a positive brush the other is connected to a bar under a negative brush; in other words, these conductors are 180 electrical degrees apart. The terminals of a balancer coil are connected to these rings by means of brushes, and a wire brought out from the midpoint of the balance coil is used as the neutral wire of the three-wire system. A second balancer coil and a second pair of slip rings displaced 90 electrical degrees from the first are also sometimes used. In this case the

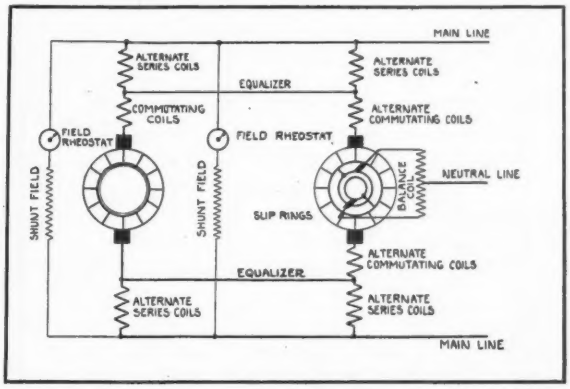


FIG 1. CONNECTIONS FOR PARALLELING A THREE-WIRE GENERATOR WITH A TWO-WIRE GENERATOR

midpoints of the two balancer coils are connected together and to the neutral line. The number of commutating poles should be the same as the number of main poles to obtain the best results, although if the load is not seriously unbalanced it is often possible to obtain satisfactory results by the use of only-half as many commutating poles as main poles. To obtain the same effect, regardless of what line carries the greater load, every alternate commutating coil, with every alternate series coil, is connected between the armature and one side of the line, while the remaining series and commutating coils are connected between the armature and the other side of the line.

With a three-wire generator the voltage always becomes unbalanced as unbalanced load is applied. The steady unbalance due to load is proportional to the unbalanced current and to the resistances of the various parts of the generator and balancer coils. With a certain unbalanced current, the voltage unbalance can be reduced by the use of two balancer coils and four slip rings instead of one coil and two slip rings. The gain, however, is usually negligible. The unbalance can also be reduced by lowering the resistances, which would usually require the use of larger generators and balancer coils. There are no other means of decreasing the unbalance of voltage.

It is sometimes impracticable to connect the slip rings to points in the armature exactly 180 electrical

degrees apart. In these cases the potential of the neutral line varies periodically from the true neutral. Such variation tends to cause a flicker of any lamp connected between the neutral and one of the main lines. The greater and the slower the variation the greater will be the flicker. Such variation occurs in most three-wire generators, but the frequency is usually so high that the flicker is not noticeable. The frequency is equal to the revolutions per second of the generator times the number of pairs of its poles. A frequency of 20 cycles or less should be avoided. This would correspond to 400 r.p.m. for a four-pole machine, and 265 r.p.m. for a six-pole machine.

Three-wire generators can be paralleled, but the process is rather complicated. They must be equalized on both sides and adjusted not only to divide the main line load properly, but also the unbalanced load.

Balancer Sets

Balancer sets consist of two duplicate motors or generators of standard construction directly coupled

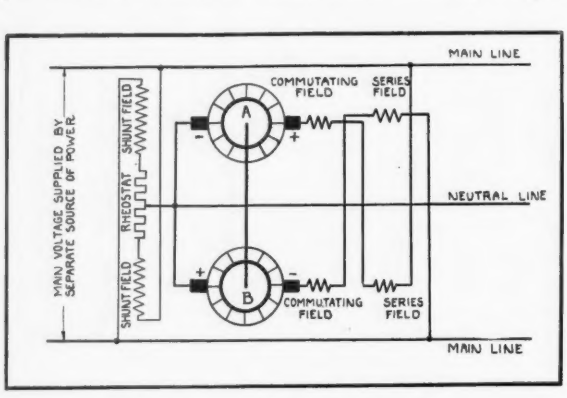


FIG. 2. BALANCER CONNECTIONS

together. Such a set does not supply power to the main lines of a three-wire system, but only maintains the neutral line at its proper potential with regard to the potentials of the main lines, the power being supplied by standard 250 v. machines.

If two duplicate, shunt-wound, standard motors, having no series or compensating coils, are coupled together and connected in series electrically, their external terminals being connected to the main lines of the three-wire systems, and the point of connection between the two machines being connected to the neutral line, the balancer set will run and tend to maintain the neutral line at approximately the true neutral. However, the potential of the neutral line will probably shift considerably as the unbalanced load increases. If the shunt fields are disconnected from the neutral wire, and are simply connected in series between the main lines, the unbalance of voltage due to the unbalance of load decreases. Neglecting the effect of the commutating fields on regulation, under this condition the amount of unbalance of voltage should depend entirely on, and be proportional to, the unbalanced currents and the resistances of the machines. If next the shunt fields are crossed, that is, if the field of machine A is excited by the voltage across the armature of generator B, and the field of generator B is excited by the voltage across the armature of generator A, as shown in Fig. 2, then the unbalance of voltage due to the unbalance of load is still further reduced. If series fields are added, and they are also crossed, that of A being excited by the armature current from B and vice versa, the set can be so adjusted that at no load and at any desired unbalanced load the neutral line has a true neutral potential. At other unbalanced loads the voltage may shift slightly, but in general the potential of the neutral line will stay at the true neutral regardless of the amount of the unbalanced load.

Periodic fluctuation of the potential of the neutral line, resulting in flicker of lights, is eliminated when balancer sets are used. Balancer sets may be made to carry any amount of unbalanced load desired. They usually can be operated in parallel. Adjustment for parallel operation is very similar to the adjustment of compound-wound generators for parallel operation. The chief difference is that all adjustments are made in duplicate for a balancer set. Both machines of a set are made exact duplicates, so that if the series field of one machine is shunted, the series field of the other machine of the same set should be shunted by exactly the same amount. Compound-wound balancer sets can always be designed for parallel operation. Shunt wound sets that are designed to keep the unbalance of voltage due to the unbalance of load as small as possible usually cannot be operated in parallel; however, if the set is designed so that the potential of the neutral line shifts decidedly as load comes on, the set can be operated in parallel with similar sets. It should be noted that compounding of a balancer set does not affect the main line voltage, but affects only the amount of unbalance of voltage resulting from unbalance of load.

Applying load to a balancer set results in an increase of the speed of the set. Such a condition in a motor alone is abnormal and is an indication of instability and so should be avoided. This is not true, however, of a balancer set. An increase of speed due to increase of load is normal for a balancer set and is not an indication of instability. The maximum speed that a set should run at is, of course, limited by the mechanical strength of the armature, but as long as that limit is not exceeded, it is immaterial at what speed a balancer set runs or how much its speed increases with load. The full-load speed of a balancer set is usually about five per cent above the no-load speed. Compound-wound sets have a greater change of speed with load than do shunt-wound sets.

Balancer sets need not be located adjacent to the generator, but can be any place between the generator and the three-wire system of distribution. For instance, if an office building were to be supplied with lights on a three-wire system and power was supplied from a 250 v. direct-current generator at some distance from the building, it would be desirable to locate the balancer set in the building near the point of local distribution, and thus avoid the voltage drop in the neutral wire which would be occasioned if the balancer set were located near the generators.

Two-Wire Generators in Series

Two generators may be connected in series and used as a source of supply of power for not only the main

line, but also for the neutral line of a three-wire system. In such a case, the outside terminals of the two generators are connected to the main line, while the midpoint between the two machines is connected to the neutral lines. Such an arrangement needs but little discussion. The field windings on the generators, whether shunt or compound, affect both the main line voltage and the unbalance of voltage due to load. If both generators are made shunt wound, the main line voltage decreases as the load increases, and the unbalance of voltage increases as the unbalanced load increases. If both generators are flat compound wound, the main line voltage and the division of voltage is practically independent of both the main line load and of the unbalance of load. Such generators will not cause flicker of lights, and may be paralleled with other generators similarly connected, by the same methods used in paralleling other generators; that is, they will carry 100 per cent unbalanced current up to the full-load current rating of the generators, that is, they will carry 100 per cent unbalanced load. Such generators of 125-v. rating can also be connected in parallel with standard 250-v. generators, provided the current unbalance does not exceed the rating of the 125-v. generators. In this case, it is necessary to split the fields of the 250-v. generator, in order to get proper equalization.

Costs

To obtain a rough idea of the comparative costs of the various sources of power, list prices were obtained for various types of machines that could be used as a source of power for a given three-wire system. The system assumed is to have a voltage of 250 v. between the main lines. The maximum continuous current in either of the main lines is taken as 400 amp. The prices for four different amounts of unbalance, expressed in terms of percentage of the price of a standard two-wire generator, are given in the accompanying table. It should be understood that these figures are approximate and that the relation between the costs will vary for different kw. systems. The costs given are on the basis of using 1150-r.p.m. generators. If the generators are to be driven at a lower speed, their price would increase while the price of the balancer set would remain unchanged. The price of the balancer set does not include the cost of the generating equipment, which is included in the other three methods of obtaining three-wire systems.

COMPARATIVE COST IN PER CENT OF THREE-WIRE 400 AMP. GENERATING SYSTEMS

Case No.	1	2	3	4
Unbalanced amperes	40	100	200	400
Cost of two-wire generator	100	100	100	100
Cost of three-wire generator	115	120	...	...
Cost of balancer set	35	45	75	110
Cost of two 125-v. generators	155	155	155	155

Summary

For the highest class of service, where it is essential to eliminate all possible flicker of lamps, and unbalance of voltage due to load the use of either compound-wound balancer sets or generators connected in series is preferable to the use of three-wire generators. Where the selection depends entirely upon the price the following conclusions may be drawn:

1—If sufficient power is available for the main lines and power for the neutral line only need be supplied, balancer sets should be used.

2—If power must be supplied to all lines, and the speed of the generator can be made relatively high, it is usually less expensive to use three-wire generators if not more than 25 per cent unbalanced load would be required of the generator. If more is required, two generators in series are usually more economical than the use of a generator and a balancer set.

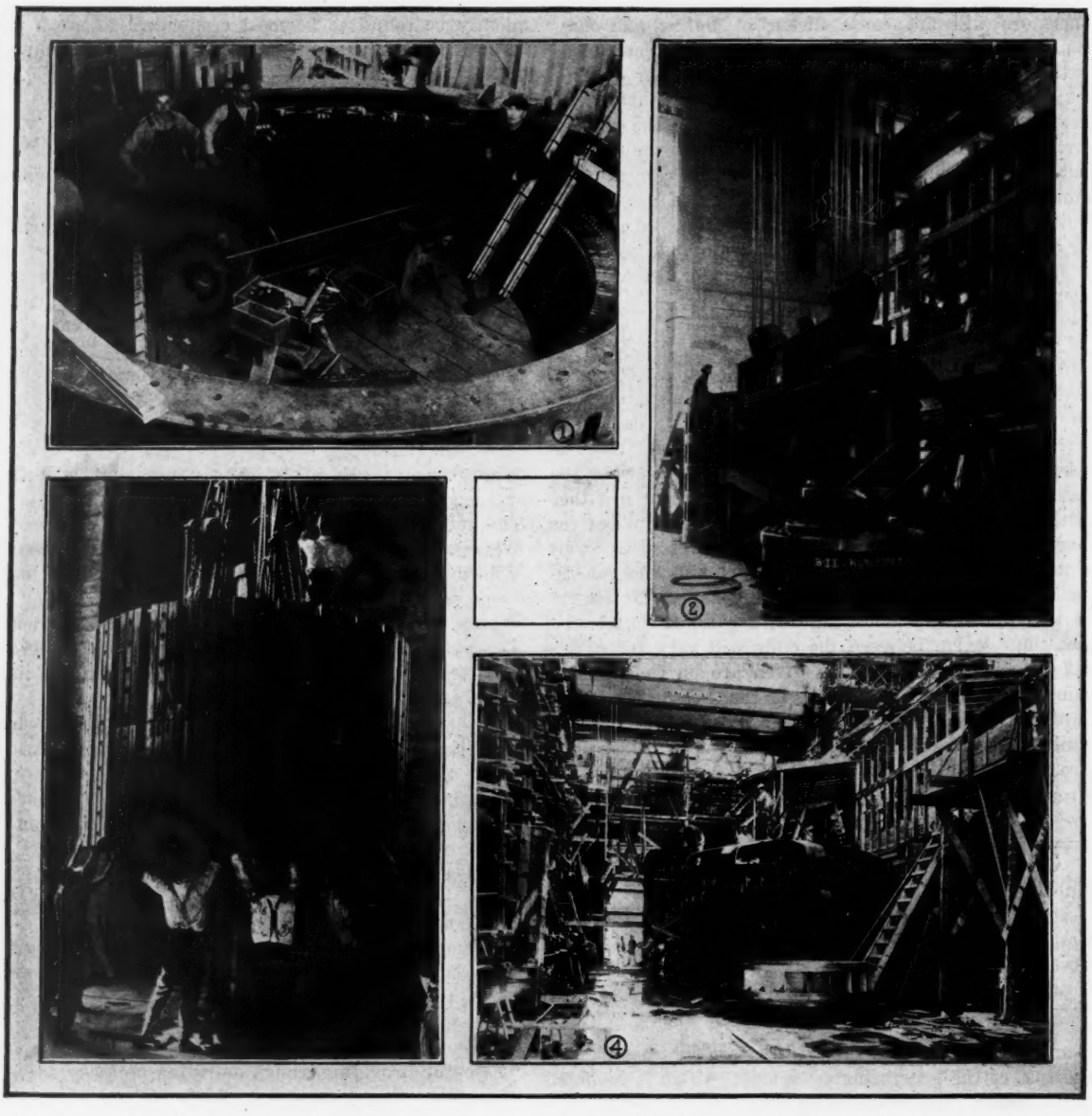
3—If very low speed generators are used it will frequently be found to be most economical to use a two-wire generator and a balancer set.—The Electric Journal.

The Engineers

Sung to the tune of "Son of a Gambolier."

WHO is the man designs our pumps with judgment, skill and care?
Who is the man who builds 'em, who keeps them in repair?
Who has to shut them down because the valve seats disappear?
The bearing-wearing, gearing-tearing *mechanical engineer.*
Who buys his juice for half a cent and wants to charge a dime?
Who when we've signed a contract can't deliver half the time?
Who thinks a loss of twenty-six per cent is nothing queer?
The volt-inducing, load-reducing *electrical engineer.*
Who is it takes a transit out to find a sewer to tap?
Who then with care extreme locates the junction on the map?
Who is it goes to dig it up and finds it nowhere near?
The mud-bespattered, torn and tattered *civil engineer.*
Who thinks without his products we would all be in the lurch?
Who has a heathen idol which he designates Research?
Who tints the creeks, perfumes the air, and makes the landscape drear?
The stink-evolving, grass-dissolving *chemical engineer.*
Who is the man who'll draw a plan for everything you desire?
From a trans-Atlantic liner to a hairpin made of wire
With "ifs" and "and," "howe'ers" and "buts," who makes his meaning clear?
The work-disdaining, fee-retaining *consulting engineer.*
Who builds a road for fifty years that disappears in two?
Then changes his identity, so no one's left to sue?
Who covers all the traveled roads with filthy oily smear?
The bump-providing, rough-on-riding *highway engineer.*
Who takes the pleasure out of life and makes existence hell?
Who'll fire a real good-looking one because she can not spell?
Who substitutes a dictaphone for coral-tinted ear?
The penny-chasing, dollar-wasting *efficiency engineer.*—(Bulletin of the Minnesota Federation of Architectural and Engineering Societies.)

Novel Method of Installing Machinery at Pit River



In the accompanying photographs are shown some novel features in connection with the installation of machinery in the new Pit River hydroelectric plant.

Figure 1 shows generator coils being put in place. These generators are so large that the iron was stacked at the coils put in on the job. Note method used to protect coils from damage during shipment.

In Fig. 2, a total weight of 187 T. is being handled by two 75-T. cranes and a specially designed equalizer beam. This beam weighs 22 T. The photograph shows the rotating element of one of the generators being lowered into position.

Figure 3 shows the rotor of one of the generators being placed on the shaft. The rotor had previously been heated in an oven while the shaft had been packed in ice. When at the same temperature the bore of the rotor is 0.002 in. smaller than the diameter of the shaft.

An interior view of the Pit River power house during construction is shown in Fig. 4.

Preheated Air Increases Air Motor Output

EXPERIMENTS AT THE UNIVERSITY OF ILLINOIS SHOW ADVANTAGES DERIVED FROM WORKING COMPRESSED AIR EXPANSIVELY AFTER REHEATING. BY C. R. RICHARDS AND J. N. VEDDER.

POWER TRANSMISSION by means of compressed air has been in use for many years because of its simplicity, the relative high efficiency of air compressors and the economy with which compressed air may be transmitted for long distances.

Air used non-expansively, as in small tools, shows a low thermal efficiency; this sacrifice is made, however, for simplicity and low initial cost; further this class of equipment is generally used intermittently. When motors are operated continuously over relatively long periods of time it becomes essential that the air be worked expansively in the motor cylinder and that every effort be made to bring about economy of operation. In Fig. 1 is shown the relatively theoretical efficiencies of air worked with and without expansion.

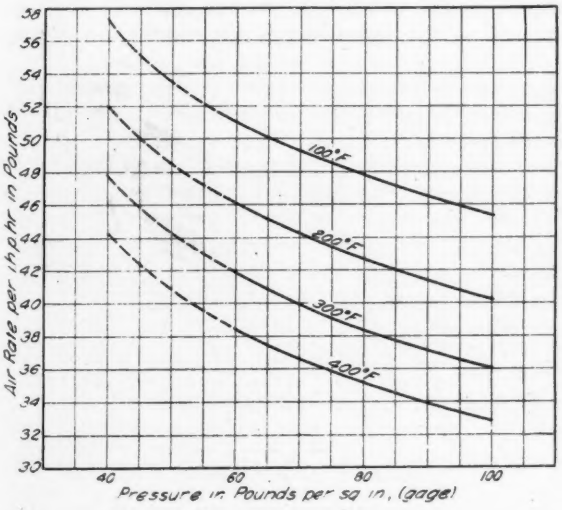


FIG. 1. COMPARISON OF THEORETICAL EFFICIENCIES OF AIR CYCLES

Heat due to compression is soon dissipated so that by the time the air reaches the motor, it is practically at room temperature. The result, then, after working this air expansively, is that the temperature has been lowered to the point where the moisture in the air will freeze, thus introducing operating difficulties of ineffective lubrication and the accumulation of ice in the exhaust pipe. Reheated air will overcome these difficulties provided that its initial temperature is high enough so that after expansion the temperature will still be above the freezing point.

Results of tests of three types of reheaters are given in Table I, the reheaters are designated as Types 1, 2 and 3. Type 1 reheater consisted of a cast-iron firebox in the form of a frustrum of a cone, with the base downward; surrounding this was a shell, thus forming an annular air space through which the air to be reheated circulates. A grate was provided upon which was maintained a coke fire. The effective heating surface of the reheaters under test was 2.9 sq. ft. and when preheating air to 400 deg. F. its capacity was about 200 cu. ft. of free air per minute. The outer shell of this reheater was at the same temperature as the heater air and losses due to radiation were not great.

Type 2 reheater consisted of a series of cast-iron coils inclosed in a casing. The air to be heated flowed through the coils. The area of the furnace and outer casing exposed to the air was large and consequently the losses due to radiation were relatively large. The heating surface of the coils was 18.6 sq. ft. Coke was used as fuel. The type 3 reheater was of the internal combustion type using gasoline as fuel. A sectional view of this reheater is shown in Fig. 2. Cold air enters at A and the heated air together with the products of com-

TABLE I. RESULTS OF TESTS OF THREE TYPES OF AIR REHEATERS

Type of Reheater	1	2	3
Length of Test	8 hr.	8 hr.	1 hr.
Pressure entering reheater, lb. per sq. in. ga.	117.4	102.3	99.7
Pressure drop through reheater, lb. per sq. in.	.....	.....	4.9
Temp. air entering Deg. F	132.7	118.8	125.3
Temp. leaving Deg. F	385.9	380.2	400
Temp. rise, Deg. F	252.3	261.4	274.7
Air reheated, lb. per hr	838	868	940
Air reheated, in cu. ft., free air per min. (62 deg. F., 14.7 lb. abs.)	183.5	190	206
Efficiency including grate, per cent	52.8	26.5	.....
Efficiency including grate, per cent	55.2	26.9	.....
Lb. Coke required to raise 1000 lb. air 100 deg. F	3.57	7.27	.....
Draft at base of stack, in water	0.35	0.35	.....
Lb. Gasoline required to raise 1000 lb. air 100 deg. F	.....	.....	1.44
Efficiency	.....	.....	84.5
Calorific value of fuel, B.t.u., per lb	12,992	12,718	20,309

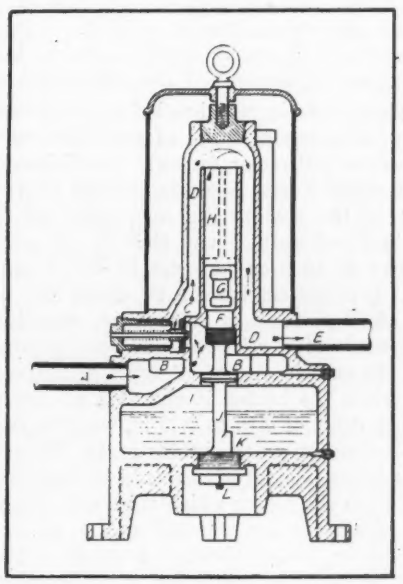


FIG. 2. SECTIONAL VIEW OF INTERNAL COMBUSTION REHEATER

bustion leave at E. The incoming air enters the space B and its pressure is exerted on the surface of the gasoline I in the base of the reheater. C is an adjustable spring loaded valve set to cause a slight reduction of pressure in the air which flows through the valve into the

TABLE II. RESULTS OF ENGINE TESTS WHEN USING REHEATED AIR

Pressure at throttle (lb. per sq. in. gal.)	60				40			
Temp. at throttle, deg. Fahr.	400	300	200	100	400	300	200	100
I. h. p.	10.9	10.8	10.9	10.8	8.8	8.4	8.7	8.4
B. h. p.	9.5	9.0	8.5	7.4	7.5	6.7	5.8	5.0
Mech. efficiency	87.1	83.7	78.0	68.6	84.8	79.6	67.0	59.8
Lbs. air per hr. per i. h. p.	40.9	44.7	47.9	56.6	47.2	52.1	55.1	62.7
Cu. ft. free air per min. per i. h. p.	8.98	9.80	10.5	12.4	10.3	11.4	12.1	13.8
Average cut-off per cent of stroke	24.8	23.8	24.1	24.8	34.7	32.7	34.0	32.5
Temp. at exhaust, deg. Fahr.	83	54	37	7	104	64	48	25

Pressure at throttle (lb. per sq. in. ga.)	100				80			
Temp. at throttle, deg. Fahr.	400	300	200	100	400	300	200	100
I. h. p.	13.7	13.4	13.5	14.1	12.7	12.5	12.4	13.2
B. h. p.	12.3	11.8	11.3	10.7	11.2	10.7	9.1	9.5
Mech. efficiency	90.2	88.1	83.2	75.7	88.2	85.1	73.7	72.0
Lb. air per hr. per i. h. p.	37.1	38.0	42.3	48.5	38.0	41.6	42.3	51.7
Cu. ft. free air per min. per i. h. p.	8.14	8.35	9.27	10.6	8.35	9.13	9.27	11.3
Average cut-off—per cent of stroke	14.2	14.8	14.5	15.8	18.6	18.6	17.5	21.1
Temp. at exhaust, deg. Fahr.	62	54	34	—11	65	39	15	—9

space D and out at E. A small tube J, having an opening, K, from the gasoline reservoir, leads to a needle valve and atomizer, F; after the atomizer a combustion tube opens directly into the space D. The difference in pressure forces gasoline upon the electrical ignition coil, G, and the gasoline mixture burns in H. Some difficulty was experienced in actual operation due to inability to keep a proper adjustment of the differential valve, C.

Complete investigation has led to the following conclusions: Commercial types of small internal combustion reheaters will under favorable conditions and when operated at their best capacity, supply 60 per cent of the heat in the fuel to the compressed air. Heating surface in direct contact with the fire pot is three times as effective as such surface not in direct contact with the fire. Internal combustion reheaters may attain efficiencies of 80 per cent or more when operating at their best capacity with reheated air temperatures of 400 deg. F. The efficiencies of all types of heaters decrease rapidly when the heater is operated at low capacities. A chimney draft of 0.15 to 0.25 in. water is essential for proper combustion on the heater grate. To avoid excessive heat losses, the reheater should be located as closely as possible to the motor which it serves. One thousand pounds of air per hour or 219 cu. ft. of free air per minute can be heated through a range of 100 deg. F. with 3¼ to 3½ lb. of fuel whose calorific value is 13,000 B.t.u. per lb.

To determine the effects of reheated air upon engine economy and operation, a series of tests was made upon an 8 by 18 in. Murray Corliss. Tests were first made to establish the efficiencies of the engine without reheat and to compare these results with those obtained under similar conditions of operation with the air heated to several different temperatures. Without reheat, difficulty was experienced, due to frosting of the exhaust pipe though the air from the compressor reached the engine at 100 deg. F. It is safe to say that under this condition the temperature of the air in the cylinder just as the valve is on the point of releasing is between 35 and 50 deg. below zero when the cutoff is from 15 to 20 per cent of the stroke, and 60 to 70 deg. below zero when the cutoff is at 20 to 25 per cent of the stroke, the temperature at the throttle being in all cases 100 deg. F. The temperature in the exhaust pipe rises as the cutoff becomes greater than 25 per cent.

Under the foregoing conditions, any moisture in the air was certain to cause operating difficulties in a few minutes. Frosting of the exhaust parts resulted in a back pressure which, if allowed to continue, would have prevented the operation of the engine. Lubrication

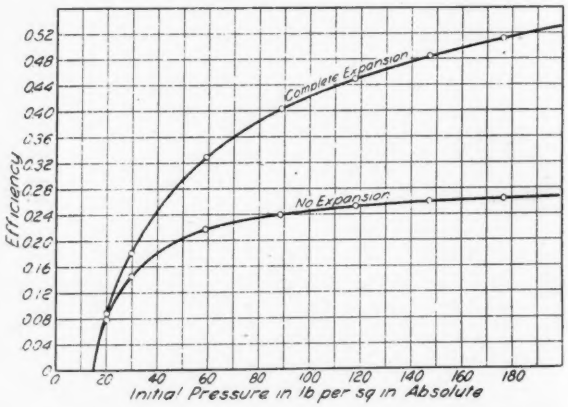


FIG. 3. AIR CONSUMPTION PER I.HP. PER HR. FOR VARIOUS THROTTLE TEMPERATURES AND GAGE PRESSURES

troubles were also caused by the low cylinder temperatures; this difficulty was particularly pronounced when a mixture of cylinder oil and graphite was used as the cylinder lubricant. These two effects of the cold caused the brake horsepower and mechanical efficiency of the engine to show considerable variation.

Table II shows the results of tests at different pressures with engine cutoff and reheated air temperatures as variables. In Fig. 3 is shown the air consumption per indicated horsepower per hour for various throttle temperatures and gage pressures.

These tests have shown that in an engine using air as the working medium the expenditure for coke for indicated horsepower per hour gained through reheating was 0.98 lb. Under the least favorable conditions of operation with cold air, the mechanical efficiency of the engine fell to 59.8 per cent, which under the best conditions of operation with reheated air the mechanical efficiency was 93.7 per cent. Further, air at 400 deg. F. will yield the same brake power with two-thirds the compressor capacity and steam consumption required when the air is used at 100 deg. F. The highest efficiencies were obtained when the cutoff was at about one-quarter of the stroke, complete expansion does not show equally good results. The use of reheated air leads to an improvement in lubrication, an astonishing increase in mechanical efficiency and the prevention of ice formation.

Common Sense a Factor in "Safety First"

By Fred S. Rutledge

SOMEBODY, once upon a time, said that it took a lot of little things to make the big things. This is very true and it surely applies in the practice and application of safety first as illustrated by the following incident:

A man employed in a shop as foreman of a part of a machine shop gang took it upon himself to go trouble shooting on an elevator when the regular man for that job was in another part of the building. This foreman had done a "little fixin' " before and that was the starting of the mess that nearly killed him. The crotch ropes to which the hand rope which centers the controller for the motor and applies the brake is attached, had become quite badly worn and he grabbed the first piece of rope handy, which happened to be ¼ in., and put that in. The original crotch was made up of two short pieces of chain, with a ring in the center to which to fasten the hand rope or brake rope. The ends of chain were fastened to the shifting cable with cable clamps. Who took the chain off has never been discovered.

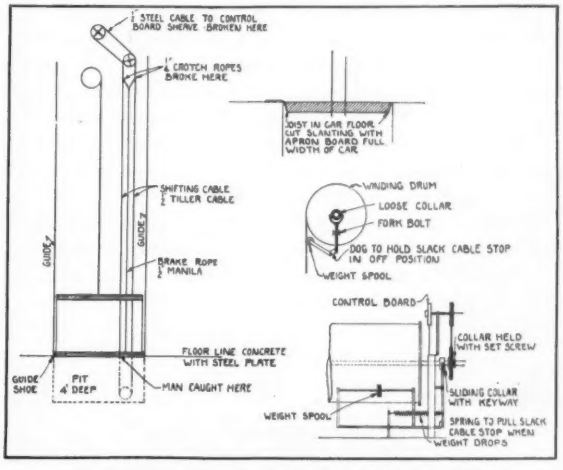
As long as I had charge of this or any other elevator, I always instructed whoever was to take charge of them in case of my absence or sickness, always to examine the brake and control rigging, in case of trouble that required getting under the car, and this man had been told the same thing repeatedly. Well, he had the operator, who was a sort of "Give a Damn Jones," raise the car up enough so that he could get down in the pit and inspect it.

When he got ready to get out, he grabbed one of the truss rods under the car and told the operator to "take her up." When about 3 ft. up from the floor, he said to stop and the operator gave a jerk on the brake rope, and one side of the crotch let loose. The other held long enough to throw the controller clear over and then it, too, let loose, the whole rope falling down on him. By the time he woke up the car had come down and caught the man between the apron board and steel plate on the edge of the pit floor line. He had started to swing out and one leg was down in the pit, the other on top of the floor and he was doubled up with the elevator car (this is a 2-T. freight elevator and car frame is made of steel) resting on top of his hip bone. The only thing that saved him from being cut in two was the fact that he was near one end of the car and the guide shoes, being loose, allowed the car to jam cornerwise in between the guides, due to the wedging of the man between the apron board and floor edge. The wedging of the car released the slack cable stop and shut off the motor, also applying the brake. The operator jumped off the car and ran away.

Attracted by the man's cries, I found him lying on the floor about 4 ft. from the elevator. He had worked himself out from under the car and rolled away that far. I picked him up and carried him to a place where he could be made comfortable until the ambulance arrived. A cracked hip bone, flesh torn loose on back and hip and on the inside of thigh of left leg, but no skin broken on the outside, was the extent of his injuries, and 19 weeks in the hospital with a 30 per cent disability for work, when able to.

Figure 1 is a sketch of the elevator. Figure 2 illustrates the apron board, and Figs. 3 and 4 slack cable stop. I had not been taking care of the elevators for over 3 yr., that work being transferred into the machinists' division under the superintendent of maintenance; but I went at once and examined the remains of the elevator so that when an investigation was made I would know something about the affair.

Two men had heard the injured man's cries and had grabbed the shifting cable when they saw the brake rope


STEEL CABLE TO CONTROL BOARD SHEAVE BROKEN HERE
CROTCH ROPES BROKE HERE
JOIST IN CAR FLOOR CUT SLANTING WITH APRON BOARD FULL WIDTH OF CAR
SHIFTING CABLE & TILLER CABLE
GUIDE
GUIDE
BRAKE ROPE & MANILA
WINDING DRUM
LOOSE COLLAR
FORK BOLT
DOG TO HOLD SLACK CABLE STOP IN OFF POSITION
WEIGHT SPOOL
CONTROL BOARD
COLLAR HELD WITH SET SCREW
FLOOR LINE CONCRETE WITH STEEL PLATE
GUIDE SHOE
PIT 4' DEEP
MAN CAUGHT HERE
SLIDING COLLAR WITH KEYWAY
WEIGHT SPOOL
SPRING TO PULL SLACK CABLE STOP WHEN WEIGHT DROPS

SKETCHES OF THE ELEVATOR MECHANISM

gone and something let loose. If the man had gone up to the control apparatus first he would have found the cause of the trouble to have been that the brake lining was loose and half of it out from under the brake band.

Moral: Too much speed and not enough brains. Results: The man listed as 30 per cent disabled for the rest of his life.

Safety first is a good thing both to practice and to preach, but how can you impress things on some men's minds when you have to write it on a piece of paper and then bore a hole in their skull and push it in and finish by corking the hole? So it goes all on down the line. Many men working in the power house apparently are bright and intelligent, quick as to bodily actions and readily pick up anything shown them if they continue to do the same thing over and over; but when an emergency arises they can't remember, today, something they were shown yesterday.

As an example, I worked as watch engineer, one time, where the lighting panels for the shop were on one half of the board and the generator and feeder panels on the other half. Current for lighting was taken from the power lines and all main line power fuses were in a concrete transformer house at one corner of the power house. Every time a fuse would blow on the power lines the man who had the title of "house electrician" would come tearing in and start testing the fuses on the lighting panels. I have seen him do it

three times in one day and once a day for six days in succession. After he was shown, each time he would say, "Well, I never knew that before." Still he was always bragging about his job and resented anyone trying to help him out. He was always saying, "Well, a first class electrician can get 80 cents an hour any place, so I guess they will not fire me. I didn't have the power to, but I often had the desire to fire him. How are you ever going to get anywhere with this type of individual?

As another example, take the job of wheeling coal from storage pile to boiler house, distance not to exceed 60 ft. I had a man on the job who would move coal in for an average of 10 cents per ton. He quit and another man was sent in who was a relative of one of the officials of the firm. He was paid 40 cents per hour and worked 5 hr., besides having two other men helping him 1½ hr. at 50 cents per hr. Four tons was the result of all the labor and the cost of wheeling was 87½ cents per ton. These are the things that make life worth while around a steam plant. The old saying goes, "The average man is worth common labor wages from the neck down." How much are you worth from there up? Mix a little brains with your labor and remember that if there is going to be any business carried on to a profit every man from the ash wheeler up or the president down must put into it, if you are so situated that you must work for someone elsefi more than you take out or it will be only a limited time until there will be nothing to take out.

Lignite Char: Its Production and Possibilities*

BUREAU OF MINES HAS BEEN LED TO INVESTIGATE CARBONIZING PROCESS AND USE OF CHAR WITHOUT BRIQUETTING. BY O. P. HOOD

ONE OF THE chief reasons for the lack of development of our lignite resources is the fact that in nearly every district where lignite should be the natural fuel, it is put in competition with high grade fuels produced in other localities. We have been spoiled by being blessed with an abundance of the best, so that we are impatient with the limitations of lower grade fuels. Canadian and North Dakota lignite must compete with anthracite and with Pittsburgh and Illinois bituminous coal; our Texas lignite must compete with gas, oil, and Oklahoma bituminous coal. It is evident, however, that there must be a price at which the lower grade fuel will begin to be attractive. In round numbers the ratio is somewhere in the neighborhood of half the price of good coal. With the rising price of bituminous coal we are fast approaching the time when this ratio will be common.

Although the handicaps of lignite are well known, they are not always properly valued. The heating values of high-moisture fuels are somewhat misleading. The heat carried by the moisture is recovered and measured in the calorimeter, but is not fully utilized in a boiler furnace. The B.t.u. ratios, therefore, do not give the relative possible steaming values of the fuels if comparison is made between a high-moisture lignite and a low-moisture bituminous coal. Although the ash percentage may be low, there is usually a larger total amount of ash to handle in a plant using lignite. The fusing temperature of the ash is usually low, making high rates of combustion difficult and requiring larger grate areas and furnace volumes than with higher-grade coal. Notwithstanding these handicaps, with present technique, raw lignite can be used in large operations, and good efficiencies and reasonable capacities can be obtained. The problem is largely an economic one. When raw lignite is cheap enough in comparison with better coals it will be used in large steam-raising operations.

*Abstract of a paper presented at the Spring Meeting of the A. S. M. E., Montreal, Canada, May 28 to 31, 1923.

IMPROVEMENT OF RAW LIGNITE FOR FUEL PURPOSES

In spite of its limitation the search for a means to improve this fuel, however, must continue. A fuel classed as lignite in northern Bohemia, and weathering much as does our lignite, is as carefully prepared for market as is our anthracite. Seven prepared sizes are offered to the market. Raw lignite can probably be somewhat improved for steam raising by sizing the product more closely than is common practice. It is probable, however, that an improved lignite product must first cater to a special trade that will pay a special price. This is illustrated by the vision that has been so frequently held of improving the lignite by some process involving briquetting. Unlike the German "Braunkohle," our lignites do not make a stable and satisfactory briquet simply by drying the lignite and briquetting by heat and pressure. They lack sufficient inherent binder to consolidate and waterproof the mass. The necessary added binder increases the cost and hardly improves the quality. A quite satisfactory fuel can, however, be made by briquetting lignite char, and it is probable that some day such a fuel will be in common use.

There have been hopes that through the recovery of by-products sufficient credits might be obtained to materially lessen the cost of briquets. Profit can be shown on paper, but such a process is essentially a large-scale operation requiring a large investment and very substantial financial backing by those familiar with technical enterprise.

LIGNITE CHAR AND ITS POSSIBILITIES

With these facts in mind, the United States Bureau of Mines is investigating the possibilities of a somewhat different program which has for its main features an inexpensive carbonizing device and the use of the lignite char direct, without briquetting. If a market for the char can be developed, and the small mine can produce char, here would be provided means for a natural evolution of an industry that in time might realize the larger vision of briquetting and recovery of by-products. Lignite char can best be described in a few words as a fuel rather near in analysis to anthracite coal, but softer, with a little more volatile matter, and thus kindling easier. In size it grades from pea coal to smaller sizes, and is a stable product. Whether a market can be developed for such a fuel at prices around five dollars a ton at the mine, remains to be shown, but it is at least encouraging to know that Germany used last year 400,000 T. of similar material for domestic heating and cooking. This fuel burns well with natural draft where

a thin fuel bed, about 1½ in. in thickness can be maintained.

Production of Lignite Char

To produce the char a very simple oven has been devised that greatly reduces the investment from that needed for ovens heretofore proposed. If lignite be passed through a combustion zone, moisture is first driven off; then combustible gases are distilled, and finally the solid carbon is burned. There is a considerable shrinkage in volume and a complete absence of caking quality. These steps are fairly distinct one from the other, so that the flow of lignite through the combustion zone may be so regulated that but little of the fixed carbon is burned. The combustion zone can be maintained by burning some of the distilled gases within the moving mass of lignite, and such direct heating is more efficient than where heat must be transmitted through refractory walls. The hot gases of combustion also pass through the mass, driving off the moisture and departing fairly cool. It is something like an open-top lime kiln. The process has proved simple and efficient. Of the gas driven off, much of it is used in the combustion zone, and in addition, less than 5 per cent of the weight of the original lignite is burned. That is to say, the fixed-carbon loss in the process for drying and distilling is lower than is usually found for drying alone where separate driers are used. Passing the combustion zone the lignite enters a lower section protected from the air, where it cools and is then removed. The char obtained by such a process may, of course, be briquetted.

An oven of this sort was operated at Grand Forks, N. D., during the past summer, and about 400 T. of various North Dakota lignites passed through. In February about 100 T. of Saskatchewan lignite was tried to discover whether this presented any special problems.

About 2½ T. of raw lignite reduce to one ton of char, and the heating value is about 12,000 B.t.u. per lb. The moisture is very low and the char can be stored without danger of fire or degradation in size. Where the freight charge is heavy it would be an advantage to ship the char instead of raw lignite.

Some Unusual Pipe Bends and Welds

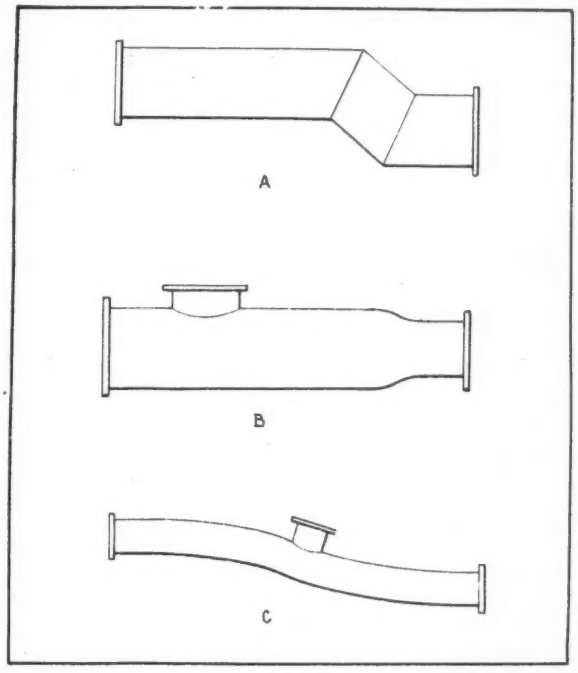
By W. F. Schaphorst

SOMETIMES it is impossible to make pipe bends that will fit into unusually cramped plant conditions. For example, a bend was wanted in a 24-in. pipe, the offset to be 21 in., and the length face to face 10 ft. 5 in. It was specified that the bend had to be made close to one end—an impossibility as ordinarily done with a pipe 24 in. in diameter. As a result, it was decided to make a "welded bend" as sketched at A in the accompanying illustration, herewith. Square lap Van Stone joints were provided at each end as shown.

The only objection to a bend of this kind is the more abrupt bend—the "corners" in the bends—and the possibility of the creation of eddy currents. Several years ago welded joints were objectionable, but today they are made just as strong and even stronger than the solid plate. Besides, the welded joint is smoother on the inside and causes less friction.

At B is shown another unusual pipe connection—a combination welding and swaging job. The 24-in. pipe was swaged down to 20 in. and was then provided with a square lap Van Stone end of standard 20-in. size. The 20-in. outlet shown at the top was welded in place; it, also, being equipped with a square lap Van Stone joint end.

Swaging pipe down in this manner has a number of advantages over other methods. If reducing fittings were used instead, the friction would be greater, more space would be required, there would be greater danger of leaks due to the greater number of joints, the completed job would not look so good, and last but certainly not least the cost with fittings would be greater. Besides, as has been proved in actual tests, the Van Stone joints far superior to ordinary joints involving pipe fittings.



SOME UNUSUAL PIPE BENDS AND WELDS

At C is shown an unusually long bend made from 18-in. pipe. It is 21 ft. 6 in. from face to face, has a 10⅞-in. offset bend and close to the center a 10-in. nozzle is welded in place as shown. If one were to attempt to make this job out of straight pipe and fittings, it is evident that the result would be a clumsy looking affair, it would cost more, and it would be far less efficient and safe.

Improvements in the quality of paper insulated, lead covered cables has made it possible to reduce the thickness of insulation without reducing the factor of safety of operation. Twelve-kv. cable, which in 1920 had insulation of approximately 13/64 in. plus 6/64 in. and which since that time has been steadily reduced so that it now has 9/64 plus 4/64 in. exceeds the voltage requirements in the breakdown tests on samples with about the same margin as they formerly did.

Overcoming Tilting Trap Troubles

USE OF RECEIVERS WITH TRAPS MAY BE EMPLOYED TO ADVANTAGE. BY H. A. JAHNKE

IN SOME power plants direct return tilting traps are used for boiler feeding and to take care of the condensation from the heating system and other steam-using apparatus in the power plant and factory a lifting trap of the tilting type is used. In most instances the lifting trap discharges the condensation directly into the direct return trap.

There is one fault I find with this arrangement, which is in cases where the direct return trap has to operate frequently in order to furnish the boiler or

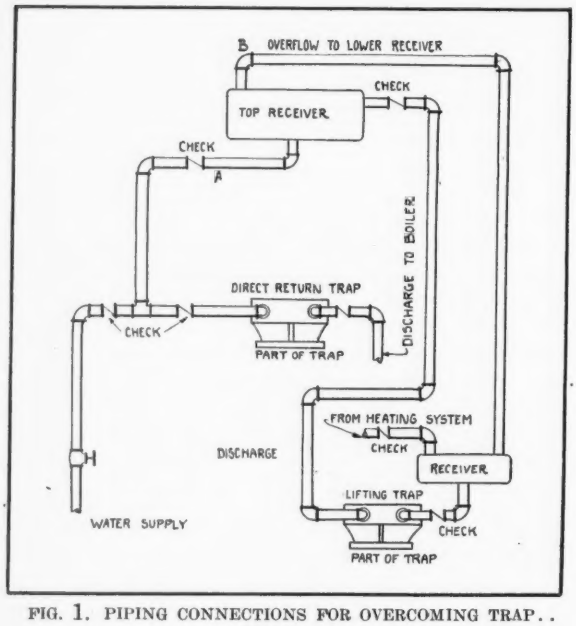


FIG. 1. PIPING CONNECTIONS FOR OVERCOMING TRAP TROUBLE

boilers with sufficient water. This requires that the water supply valve to the trap be wide open during the time the trap is in operation to feed the boiler. And as may be the case when the lifting trap is to discharge the condensation into the direct return trap, it finds this in the dumping position, hence cannot discharge the water until the tank on the direct return trap goes into the filling position again. This occurs a number of times during the day and as a consequence the lifting trap is not able to discharge at once and as often as necessary to take care of the condensation. Hence the condensate receiver from which the lifting trap receives the water as well as parts of the return pipes of the heating system is liable to fill with condensate and cause trouble; or if there is an overflow on the condensate receiver as happens frequently in some plants, much condensate goes to waste.

To overcome this trouble and waste, I have found it a good idea not to discharge the condensate directly into the direct return trap, but to connect the discharge pipe of the lifting trap into a receiver which is located about 4 or 5 ft. higher than the direct return trap. The condensation will then run into the direct return trap by gravity from top of receiver through pipe the instant the direct return trap goes into the filling position. Thus, the lifting trap will not be delayed in discharging the condensate and thereby keep the condensate receiver clear at all times. The condensate receiver at the end of the lifting trap discharge pipe should be twice the size of the one into which the condensate from the heating system, etc., runs. This is so that, should the top receiver not be entirely empty at times, the lifting trap will still be able to discharge the condensate completely. The arrangement of the piping, top and lower receivers as well as direct return and lifting trap, is shown in Fig. 1. All check valves in the system must be of the swing type and always be in a tight

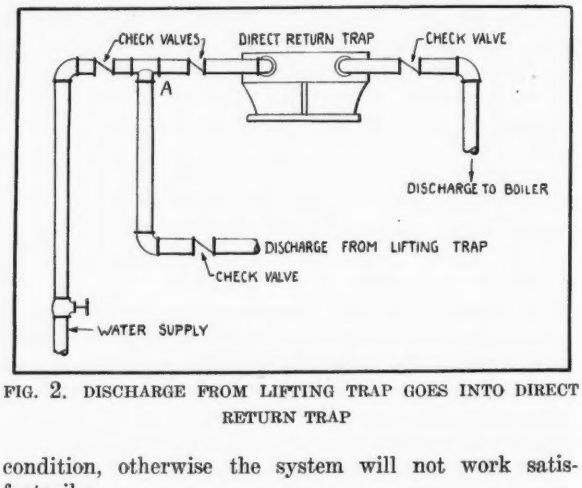


FIG. 2. DISCHARGE FROM LIFTING TRAP GOES INTO DIRECT RETURN TRAP

condition, otherwise the system will not work satisfactorily.

If for any reason the top receiver should fill up with condensate, there is an overflow pipe, B, which drains the condensate back into the lower receiver again until the trouble is remedied, which may be that some of the check valves are leaking or the direct return trap is out of order. This is noticed by the lifting trap operating oftener than usual.

TRAPS OF AMPLE SIZE

In steam plants where the direct return boiler feed trap and the lifting trap are of ample size the trouble referred to above does not occur as the direct return trap remains in the filling position longer. This gives the lifting trap an opportunity to discharge more freely at almost any time. In some steam plants we find cases where they use traps for boiler feeding and for taking care of the condensate a lifting trap is used; but there is no water heater or hot water tank to heat the water before it goes into the direct return boiler feed trap. Cold water is therefore supplied to the trap. As a tilting or any other type of trap makes much noise when supplied with cold water, where these conditions exist there is not only much noise and vibrating of pipes but there also is the danger of breaking some of the joints, fittings, etc.

It is a much better plan, in this case, to furnish all the water to the direct return trap with the lifting trap. With this plan the cold water coming in con-

tact with the hot returns in the condensate receiver from the heating system becomes heated. Warm and hot water therefore goes into the boiler feed trap, thereby reducing the noise and vibrating in the direct return trap and pipes.

Where this system is used, the lifting trap must be of a larger size than when used only for taking care of the condensate from the heating system, due to the fact that it must also furnish sufficient makeup water to the boiler feed trap that otherwise is furnished by a supply pipe direct to the feed trap. Of course the makeup water supply pipe must be connected into the condensate receiver. The pipe system should be arranged so as still to be able to furnish water directly to the direct return boiler feed trap as plant must be kept in operation regardless of the lifting trap being out of order.

Preventing Noise in Trap and Pipe

Lifting traps of the tilting type often discharge the condensate into the water supply pipe of a direct return tubular boiler feed trap as shown in Fig. 2, at A. Should the water supply valve in the water line be open and cold water enter the direct return trap, and when the lifting trap discharges the hot condensate into the water supply pipe, then when this hot condensate comes in contact with the cold water it causes much noise and vibration. This noise is much worse at times when the lifting trap does not return into the filling position immediately after all the water has been discharged, hence steam blows through the trap and much noise and vibration results. This trouble can be overcome by the system illustrated in Fig. 1.

Care of the Venturi Meter

By Claude C. Brown

VENTURI METERS should be taken out of service and thoroughly cleaned at periodic intervals, the length of interval depending upon the character of service for which the meter is used. The action of the venturi meter, depending as it does upon the pressure differential between the line pressure and that in the throat of the meter tube, is greatly affected by any variation in the throat area. For this reason any deposit that collects inside the venturi tube reduces the throat area and tends to increase the velocity through the throat of the tube, consequently increasing the pressure differential between the throat pressure and the line pressure.

This increase in pressure differential (the pressure differential being the direct measure of the rate of flow of the passing fluid), is thus raised to an erroneous figure and the meter reads high. This trouble has been especially noticed in connection with the use of the venturi meter for the measurement of hot boiler feed waters which contain scale forming salts. These salts such as calcium carbonate and sulphates tend to become deposited in a layer upon the inside of the throat of the tube causing the error in measurement to increase as the thickness of the layer increases.

At the same time that the tube is taken down for cleaning, the pressure leads to the register and recorder should be disconnected and flushed out. This is important for the reason that sediment and rust are bound to collect in these lines and any stoppage in either of the two lines causes an error in the reading.

All leaks should be immediately taken up, either in the venturi tube or in the pressure leads, for it is obvious that a leak in either of the pressure lines will result in the pressure in that line being lowered and as the pressure differential is small at best any drop in pressure in either line has a material effect upon the reading of the meter.

Best results are obtained if the two small pressure pipes that connect the meter tube with the recording and registering instrument are made of brass or copper, or non-corrosive material. When installed they should have either an up or down grade and should contain no summits or depressions where air or silt might collect. A valve should be placed on each pressure pipe close to the pressure tube. Connection between the pressure leads and the venturi tube should be made at the side of the latter and not at the top or bottom. If a summit or depression is absolutely unavoidable in the pressure leads, a blowoff valve should be placed at such point.

In case the pressure pipes are extremely long, they should be made ample size. If the length is 100 ft. or less, these leads should be ¾ in. in diameter; if the length is in excess of 100 ft., 1 in. diameter pipe should be used.

Where venturi meters are used in connection with reciprocating pumps, it is advantageous to install air chambers on the discharges of the pumps so that the oscillations and pulsations of the pump will be minimized. If this is not feasible, the meter tube should be located on the far side of heaters, filters, or economizers, as these will tend to reduce such pulsations.

Why an Engine Is Called She

Scene: A busy engine room with the engineer studying over the records of the previous day.

Enter a visitor, one of the kind who has just dropped in to pass the time of day, and incidentally waste the time of the engineer.

Visitor: "How is the engine running?"

Engineer: "She isn't doing so bad."

Visitor: "Why do you call the machine 'She'?"

Engineer: "Because she reminds me of a human in many ways. Like some women, she behaves better when she has a good reliable man to look after her; most folks have a bit of crankiness and you will notice that she also has a bit of a crank, in which she differs from the boss who is nearly all crank. She also has a bed upon which she lies; she has a head, chest and wrist and wears several rings and pins just like the women. Like most indoor workers, she needs doses of oil to lubricate her interior and, if she gets hot, she is liable to do more harm to herself than to anything else, wherein she still resembles a human. But in one important point she differs from some humans. She never asks fool questions when a man is busy."

Toronto, Ontario, Canada. James E. Noble.

Correction Note

On page 598 of our June 1 issue in an article "Checking Up on Combustion," the figure 56 was inadvertently given as the molecular weight of carbon monoxide. Manifestly this should read 28.

Use of Turbine Pumps Affects Governor Design

In Power Plant Engineering of March 15 there appeared an article under the above heading, also sketches showing two types of differential governors to be used principally on boiler feed pumps. The writer of this article (having several years' practical experience in the operation of power plants and also in the operation of several different types of differential and constant pressure governors, both on reciprocating as well as on centrifugal or turbine pumps) offers a little criticism on these two governors and shows the accompanying sketch of a type of governor that is used considerably in power plants, either as a differential or constant pressure governor with very good results.

Referring to the article of March 15, it is agreed that the governor with lever and weight gives very unsatisfactory results, and is not very dependable for good regulation, there are three outstanding points on the other type of governor that seem to be overcome in the governor described below and shown in the accompanying sketches. The points are as follows:

1. There are two diaphragms to contend with, one with pressure on both sides, the other with pressure on one side and only atmospheric pressure on the other side. For many years back, the operating man in the power plant has looked forward to a time when there would be no such a piece of apparatus in his plant as a diaphragm.

2. The steam pressure from which the diaphragms are operated is obtained by leakage at the valve steam. In many plants we find a pressure drop of from 10 to 15 lb. (and ofttimes considerably more) between the boiler pressure and the pressure on the auxiliary header supplying steam to feed pumps, etc. This drop in pressure varies with the load; there is also considerable drop in pressure due to the high velocity of steam passing through the governor valve, and if these diaphragms are designed for say a differential of 50 lb. between the throttle pressure and the pump discharge, this would not be a differential or excess pressure of 50 lb. between the pump discharge and the boiler pressure; the differential or excess pressure would vary somewhat, causing a very uneven water level and a very uneven flow meter chart on feed line, as the pressure or excess pressure cannot be properly set between the throttle pressure and pump discharge pressure to maintain an even differential between the boiler pressure and pump discharge pressure.

3. To replace one or both of these diaphragms, means that the feed pump or piece of apparatus to which the governor is attached must be entirely shut down to make the repair, for if the pump is running, the steam leakage by the valve stem makes it impossible to work on the smaller diaphragm at all.

In the accompanying sketches is shown a governor which can be used either as a constant pressure governor by not making the connection to the main boiler header, or with this connection made the same governor can be used as a differential or excess pressure governor. As will be seen, there are no diaphragms, pilot valves, reciprocating rods in packing glands, no internal mechanisms of any kind, the only adjustment to be made is on the tension of a small but extra long outside spring; the operating cylinder and plunger being entirely separate from the governor valve body.

Steam pressure working the long plunger in this external cylinder is taken from the boiler main, the pump

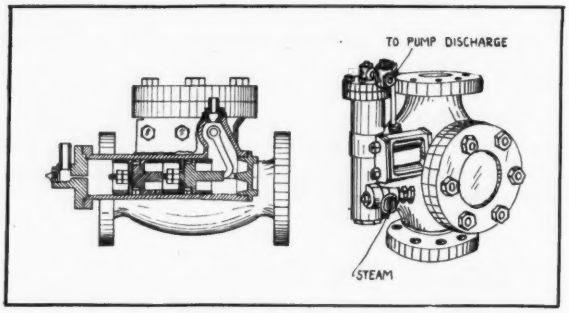


FIG. 1. THIS GOVERNOR MAY RE USED EITHER AS A CONSTANT PRESSURE OR AS A DIFFERENTIAL EXCESS PRESSURE GOVERNOR

discharge pressure working on the other end of this plunger, so there can be constantly maintained an even differential or excess pressure between the pump discharge and the boiler pressure, regardless of the pressure drop between the boilers and throttle pressure at the pump. The external cylinder with plunger, etc., can be entirely removed from the governor for inspection if ever necessary without stopping the unit, as same can be operated on the throttle during this short period. The valve proper is a balanced doubled ported disc actuated by a monel shaft which in turn is operated by the plunger in the external cylinder; this monel shaft rotates, thus eliminating the variable friction encountered with a reciprocating spindle through a packing gland. The spring is attached to the rotating shaft (which only rotates about 40 deg. for extreme travels) by a spring arm, so that the boiler pressure and spring tension, act together, tending to open the valve. The feed line or pump discharge pressure is therefore in excess of the boiler pressure an amount in direct proportion to the tension of the spring. This spring arm is so proportioned that it compensates for the increased tension of the spring when extended by the decrease of its effective moment.

This governor under suitable conditions can also be used as a reducing valve for which purpose it provides positive action, reliability and freedom from all pilot control and diaphragm troubles. The accompanying charts show the operation of this governor on an excess or differential of about 30 lb., showing the evenness with which the pump discharge pressure follows with every variation of steam pressure. WM. H. BURTON.

Air Trapped Between Layers of Belt Causes Damage

IT HAS always been a belief of ours that it would be advantageous to perforate heavy, wide belts with many small holes to allow the air trapped between the belt and pulley to escape. In examining our heavy belts which develop defects, we find in many cases that the plies have separated and air apparently imprisoned in the pockets is compressed and extends the cavity, and finally breaks through the outer layer of leather. We had a 36-in., three-ply leather belt develop this kind of trouble and apparently the air pressure as it ran on the pulley at a speed of nearly 5000 ft. per min. was sufficient to rip off a piece of the outer layer and throw it out far enough for it to catch on something and tear out a strip 3 ft. long and 8 in. wide.

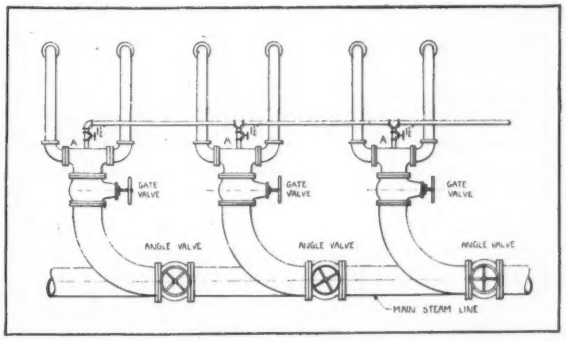
A repair was made by putting the clamps on and taking the tension off the damaged part, loosening all the layers at this point and cementing them down. Before cementing, all surfaces were scraped thoroughly. The top layer was filled in by trimming away to a width of 14 in. and laying in a strip of old belt that fitted in snugly, and cementing thoroughly. In cementing single-ply belt, it is necessary to make a long bevel at least 6 in. for 6-in. width of belt, but for two or more plies the bevel need be only 4 in. To make a good splice, the glue should be brushed in the surfaces thoroughly and the two parts hammered and rubbed, the idea being to bring the surfaces as near in actual contact as possible with no surplus glue in the joint.

In laying in a piece in a joint in a multiple-ply belt, it is always better to use old belt that has been well stretched. Even then the tension is not likely to be the same in all parts of the joints; but it will be much more nearly so than if new belt had been used. We find it much better to make our own glue for this purpose, using common glue as a base; in this way we can always have fresh glue in good condition. Belt glue is hard to keep for any length of time, especially in warm weather. J. O. BENEFIEL.

Anderson, Ind.

Piping an Auxiliary Steam Line

IN A PLANT in New York City where I was employed, no provision had been made for auxiliary steam service as most of the pumps were motor driven, and what steam was used for other purposes than to drive the main engines was taken from the main line. Consequently, when the plant was shut down at night, no steam was available. Later, it became necessary to use some lights and a small elevator at night, so a small engine and generator were added to the equipment for that purpose. It was then decided to install an auxiliary steam line to supply the new engine. There was no extra steam outlet on the boilers, where connection could be made, holes were drilled and tapped in the tees, as marked A, A, A in the accompanying sketch, for 1½-in. nipples. On account of lack of headroom the holes could not be drilled in the top of the tees as they should have been. The 2-in. auxiliary line was brought on top of the branch pipes to the boilers, with 45-deg. elbows in the 1½-in. branches (not shown in the sketch). From No. 1 boiler a 1½-in. line was run to No. 2 boiler and a 2-in. line from there on to the new engine, taps being taken off this line for the injector, a small vacuum pump,



PLAN OF STEAM PIPING SHOWING 2-IN. AUXILIARY HEADER

and an air-compressor for the sprinkler system. The valves on the main line could then be closed and steam taken from any boiler for auxiliary purposes.

Camden, Me. M. M. BROWN.

Use of Oil Grooves

MR. WHITE'S letter on "Oil Grooves on the Journal," page 645, June 15 issue, is interesting, but I do not quite agree with the methods he advocates. Shafts will run in bearings more or less satisfactorily, under various conditions as to design, load, methods of applying the lubricant, different lubricants that may be used, and different methods of oil grooving. Upon an analysis of all the conditions that should be considered, it has been found that seldom are any oil grooves required, either in the bearing or on the journal.

The primary purpose of "oiling" a bearing is to form a film of oil between the metallic parts, in order to replace metallic friction—which would exist if metal to metal contact should occur—with fluid friction.

It is known that we cannot entirely do away with friction, but of the two evils we choose the lesser; namely, we endure fluid friction rather than metallic friction, and thus save wear and tear of our machinery. Not only must the film of oil be formed for the separation of journal and its bearing, but it must also be maintained as long as the journal revolves. Under ordinary conditions no oil groove will be necessary either to form the film or to maintain it. In fact, oil grooves in either the bearing or on the journal would tend to break the film and act as a scraper to remove the oil. In no case should an oil groove be cut in that part of a bearing that supports the shaft, as that is the part that is most in need of the formation and maintenance of an oil film.

If it is considered necessary that oil grooves be cut, then cut them in that part of the bearing surface where

there is no pressure or where the pressure is least. There are many bearings on all kinds of machines running today that have no oil grooves, and they are running well and giving entire satisfaction.

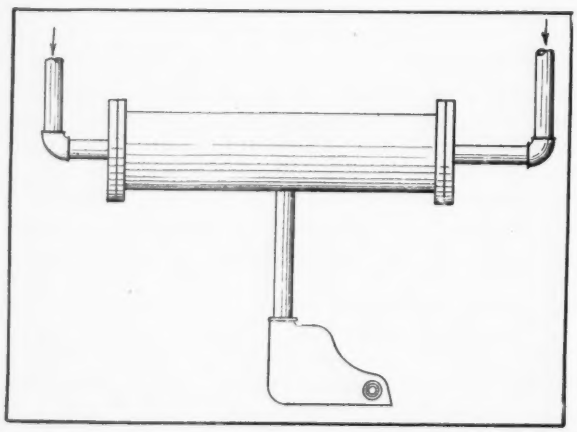
Much depends upon the kind of oil that is used in any given case, as to whether or not oil grooves will be necessary. If a heavy body oil were to be applied to a close-fitting bearing running at high speed, an oil groove would be required to distribute the oil. But that would only be a makeshift without getting at the root of the matter. With a suitable body oil for the attending conditions of speed, clearance, temperature, method of application of the lubricant, the bearing will not require oil grooves and all purposes of lubrication will be fulfilled.

In some makes of automobile engines, the crankshaft and crankpin bearings not only have no oil grooves, but they also do not have the usual chamfered edges such as we find in engine and marine engine bearings. Yet with correct lubrication these bearings stand up well, which would not be the case if grooves had been cut. Undoubtedly the unbroken surface is best for lubrication requirements, and only in special and peculiar cases are oil grooves justifiable. CHARLES J. MASON.

Brooklyn, N. J.

Increasing the Capacity of a Trap

IN OUR closed type feed water heater, we had a trap installed for draining the condensate back to the return tank; for we had installed a separator ahead of the coils, and could therefore use the condensed steam



ARRANGEMENT FOR INCREASING THE RECEIVER CAPACITY OF A TRAP

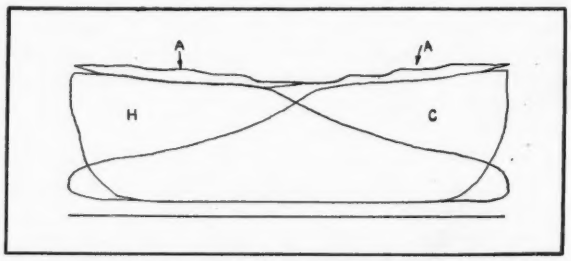
as boiler feed. We recently put in two new boilers which materially increased the load on the heater, consequently the quantity of condensate it had to handle—so much so that we were confronted with installing an additional trap or increasing the capacity of the present one.

We finally accomplished our purpose by means of an arrangement as shown in the accompanying sketch whereby we took off an additional drain connection from the other end of the heater, and brought the two together into a receiver below, made up of 6-in. pipe, which in turn connected into the trap. The receiver action provided in the 6-in. pipe served to store up the water so that it could be taken away by the trap continuously and most efficiently, and in actual practice it worked out well, at the same time saving the price of an additional trap. It seems to the writer that some such provision for storage or receiver capacity ahead of traps could be used to advantage in many cases. M. A. SALLER.

Philadelphia, Pa.

Wiredrawing Occurs Ahead of Admission Valve

I WAS recently working on an engine where I found a considerable drop of pressure between boiler and cylinder. An indicator was attached to the bottom of



INDICATOR CARDS FROM THROTTLE VALVE AND STEAM CHEST

the throttle valve where the steam pressure could be obtained before it entered the steam chest. Another indicator was placed on the cylinder. The same spring was used in both instruments. Card A was taken from the throttle valve, and the atmospheric line drawn; this card was removed and placed on the drum of indicator on the cylinder, in such position that the atmospheric line here would coincide with former one drawn. Diagrams were then taken from the cylinder. This was the high-pressure cylinder of a compound condensing engine.

Looking at card A, it is seen that with the opening of the steam valves, there is a drop in the steam line, on each end, which closely follows the curve or drop in the steam line of the cylinder card. These cards go to show that the wiredrawing and loss of pressure occur before they reach the steam chest of the cylinder.

TOM JONES.

The Business of Swearing

TO HAVE a large vocabulary of swear words may be a mental accomplishment, but it is a poor business asset. In certain important emergencies, it may be necessary to swear; but I can think of no such emergencies. Swear words are usually superfluous.

I once heard a "gentleman who swears" say this: "What ——— ——— is the ——— ——— matter with that ——— ——— ——— ——— ——— ——— ——— ——— pipe?"

Altogether he used 19 words. The words left blank are the superfluous words—swear words plus such regular words as "a", "the", and "of" which are interwoven with the others to add euphoniousness and to make the sentence sound grammatical. Twelve of these words—63 per cent— are superfluous.

If this man's time is worth anything at all, if he considers himself a first class business man, it should interest

him to know that he is wasting 63 per cent of his time using unnecessary words. The sentence is only 27 per cent efficient.

He was talking to a subordinate. He was therefore wasting the time of his subordinate as well as his own. The subordinate was obliged to listen to the entire sentence and out of it select the essential words, namely: "What is the matter with that pipe?"

There is the possibility too that the subordinate has less regard for his superior because of the latter's habit of swearing. Or, he may have assumed that his superior was simply joking. Many men swear because they seem to consider it a manly art and they swear purely for the sake of practice. Hence the added problem for the subordinate; he must be a clairvoyant.

I have often conversed with swearing men, on important matters as well as unimportant matters. Sometimes I understand perfectly. Sometimes I am amused. Sometimes I am disgusted. Sometimes I pay more attention to the swear words than to the essential words and therefore do not get the meaning at all. My mind becomes cluttered up with the chaff and the wheat does not go through. By concentrating, I can understand the average swearing man; but if a man swears as he talks, one has a good alibi if the thought fails to hit its mark. One can always say to one's swearing superior, "Why I didn't understand you that way. I thought you were only going through your daily swearing exercises." Or, "I didn't know you were serious. I thought you were only joking."

Neither is the swearing man at his best while he swears. To be an "expert swearer" he must be ever on the alert, for perchance there may be a lady within earshot. If the lady overhears the superfluous words, and if the real "gentlemen swearer" knows it, he is embarrassed. When, "caught at it," what seems to provoke him most is NOT that he swore but that he was so stupid as to swear within the hearing of a lady. Besides, if the lady is an acquaintance the "gentleman swearer" feels obliged to apologize for his "French" as he calls it. He laughs and treats the matter as lightly as possible.

The writer maintains that it is difficult enough to speak English or any other language correctly without making it still harder by injecting superfluous words that are only liable to cause trouble or embarrassment or that may do immeasurable harm. The objection to swearing is more than a mere social or moral objection. Some business men claim that they have no social ambitions whatever, that they are purely *business men* through and through.

Very well. I believe I have proved that swearing tends toward inefficiency and disrespect. That at least is what I have been aiming at. According to my logic, if it be logic, swearing will be avoided by the business man who is striving toward 100 per cent efficiency.

Newark, N. J. W. F. SCHAPHORST.

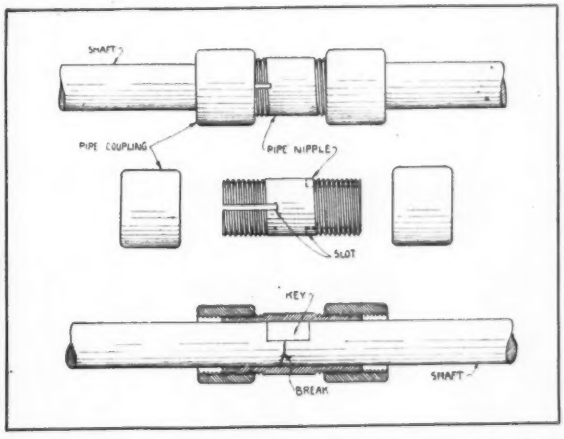
Removal of Rusted Pipe

HAVING CONSIDERABLE trouble in trying to remove from a boiler a short piece of pipe that leaked, and was corroded and burned so badly that it was too thin and weak to stand the pipe wrench, I took a blunt cape chisel and hammer, and bent the pipe in at the seam, up against the boiler shell, this started the joint, and relieved the strain of the pipe where it was screwed into the boiler shell. I then put plenty of thin oil on the portion of the threads that I had dented in with the cape chisel. By turning the pipe back and forth as much as possible until I got the oil worked in on all the threads, and in this way I loosened the pipe easily.

Badly rusted pipe can be removed from places where it is hard to get at with a wrench by the use of oil, this insures against the unpleasant experience of breaking a portion of the threads off in the flange fitting. C. F. R.

Simple Shaft Coupling Makes an Emergency Repair

IN THE acompanying sketch is shown an unusual repair coupling, which was used on a drive shaft of a truck, avoiding disassembly of the mechanism and



PIPE COUPLING AND NIPPLE AS USED TO REPAIR BROKEN SHAFT

putting the truck back into operation after only a couple of hours delay.

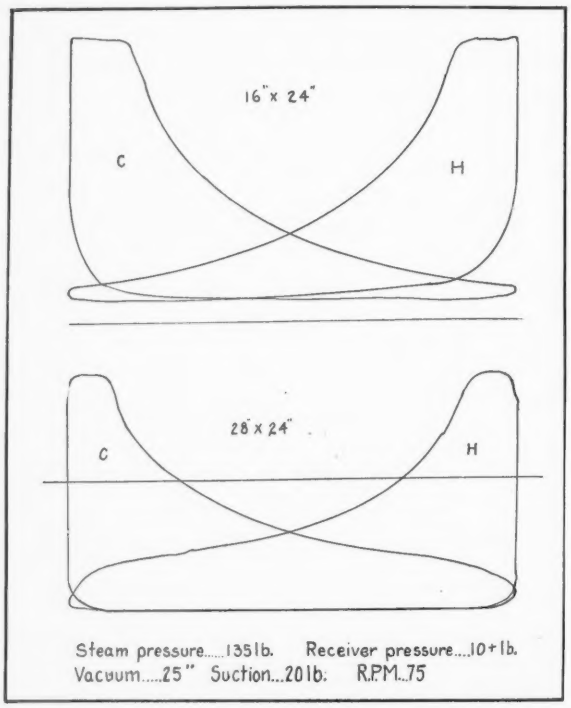
The shaft repaired was exposed and the coupling made, had ample clearance for rotation, which factor accounts for the success of this somewhat difficult job. The work was accomplished by cutting sections out of each end of the break, and inserting a semi-circular section of shafting. This work was possible to complete without machining, entailing only the use of a hacksaw. A pipe nipple was secured, which part fitted fairly close about the shaft. One end of this was slotted and at right angles to this slot; the opposite end was cut.

Two pipe couplings formed compression joints, due to the taper of the pipe thread. The broken shaft permitted of assembling this joint, and inserting the key, after which the couplings were clamped up solidly. The drive is through the larger pipe, the key being a precautionary feature. While the shaft has not broken nor showed an evidence of further trouble, a test of the joint is not obtainable; however, the assembly has the features of being most substantial and practical, and should find reasonable recognition for similar repairs, necessitated in broken shafting of almost any torsion members of machinery.

Washington, D. C. G. A. LUERS.

Should Well Enough Be Left Alone?

THE ACCOMPANYING cards were taken from a single eccentric, 16 and 28 by 24 in. tandem compound Corliss engine running condensing. This engine is driving a vertical duplex, single acting, ammonia compressor,



INDICATOR CARDS FOR CORLISS ENGINE DRIVING AN AMMONIA COMPRESSOR

cylinders 15 by 24 in. At the time these cards were taken we had a suction of 20 lb. and a condenser or head pressure of 185 lb. gage. This engine is eleven years old and shows many signs of neglect.

The valve gear is badly worn and noisy especially when operating at 70 r.p.m. or more. The high pressure cylinder, piston and rings are in almost perfect condition. The low pressure cylinder and piston are worn considerable out of round, owing to the design and construction of the piston, which is of the box type, 28 in. in diameter and 13 in. thick. The cylinder was intended for a 30 in. stroke, but they used it for 24 in. stroke by adding enough to the piston to take up the clearance. All of this weight rides on the bottom of the cylinder and as the cylinder and piston wear this weight is partly carried by the piston rod, which soon wears the packing down. I found the rod to be nearly 1/16 out of round; this was hard to pack, and worse to keep tight.

As the management would not consider the expense of reboring the cylinder and a new piston, I took it upon myself to try out something. This may not be new to many of you, however, it has proven satisfactory to us so far. This being a tandem engine, the low pressure rod runs through both heads of the cylinder. I cast two babbit rings that would fill the stuffing box for two in., machined these to fit the box and rod, made these two in. long, cut them in half, eased them off a little, then slipped them to the back end of stuffing box in place of the first two rings of packing. Then I packed in the usual manner, kept the rod lubricated and the results have been pleasing so far. The rod runs central and stays packed. The babbit rings carry the weight of the piston.

This is, however, only a small part of what has been done to this engine. We consider that it is working in a satisfactory manner at present. The low pressure cards could be improved. What do some of the readers think about making changes to make a better looking card, if engine is working satisfactory.G. L. B.

Spray Pond Design

IN THE July 15 issue of Power Plant Engineering, page 746, C. W. F. asks what size spray pond will be required and how many nozzles he will need for a 500-hp. cross compound Corliss engine.

While the quantity of cooling water used at present is not stated, I have attempted to estimate it as follows: The 500-hp. engine at 17 lb. of steam per hp.-hr. equals 8500 lb. of steam per hour, which is equal to approximately 17 g.p.m. condensate. The cooling given, from 118 to 84 deg. F., covers an interval of 34 deg. F. and in order to maintain equilibrium the rise in temperature of the water on passing through the condenser should be the same. Assuming that the steam contains approximately 1000 B.t.u. per lb. and dividing by 34 gives us approximately 30 to 1 as the ratio of circulating water to steam. In other words, 30 lb. of water multiplied by 34 deg. rise in temperature of the water equals approximately 1000 B.t.u. Now, multiplying the 8500 lb. of steam per hour by the ratio of 30 gives us approximately 510 g.p.m. for the amount of cooling water. (I wonder how near this is to the actual amount.

If this figure is fairly accurate, then a cooling pond operating with air at 70 deg., and 70 per cent relative humidity, should cool the water at full load on the engine from a 121 to 89 deg. F. and if the surface condenser is capable of operating with a difference of 10 deg. between the temperature of the discharge water and the temperature of the vacuum. That this vacuum should be 25.35 in. compared with a 30-in. barometer. I believe, however, that it would be well if possible to run the pump a little faster and circulate 600 g.p.m.,

which would increase the ratio of water to steam from 30 to 1 to 35 to 1 and under the same atmospheric conditions the water should leave the condenser at 114 deg. and be cooled to 86.5 deg., thus enabling a vacuum of 26.15 in. to be maintained with a 10-deg. terminal difference, provided the condenser is in good condition and the piping is free from air leaks. Most Corliss engines are designed to operate at best efficiency with about 26 in. vacuum referred to a 30 in. barometer and this increase in ratio should improve the vacuum approximately 0.65 in.

A cooling pond having a capacity of 600 g.p.m. would require 15 nozzles with a capacity of 40 g.p.m. each. The size of the pond should be about 50 ft. wide by 75 ft. long in order to catch the majority of the drift during windy weather.

The theoretical loss from evaporation of this pond should not exceed 1.6 per cent of the water sprayed when the temperature of the water does not exceed 120 deg. F. and the temperature of the air not over 90 deg. F. with not more than 60 per cent relative humidity. Adding to this approximately 0.2 per cent of the total amount of make-up water less than 2 per cent of the total amount of the water sprayed; that is, in this case the maximum amount of make-up water required to keep the pond at a constant level should not exceed 12 g.p.m. in hot summer weather and less than one-half of that amount in winter, assuming a location in the central part of the United States.

It is important to have a sufficient amount of circulating water to keep the temperature of the water discharged from the condenser at such a point as to obtain a good vacuum which I believe should be 26 in. compared to a 30-in. barometer for cross compound Corliss engines.

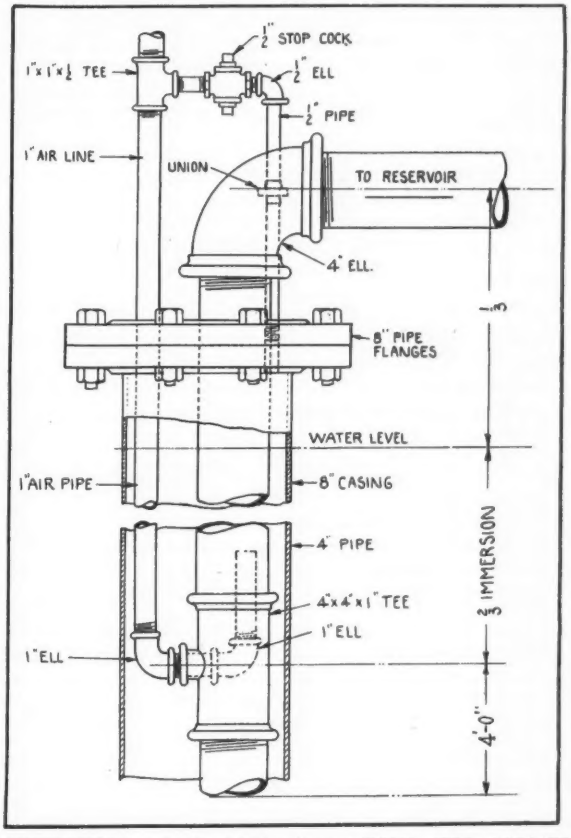
B. R. T. C.

Economical Air Lift Installation

Referring to C. D. R.'s article under the caption, "Which Type Will Be the Most Economical," in the June 15 issue of Power Plant Engineering, I would say that from my personal experience none of the three methods is as economical as it should be. The accompanying sketch shows a more economical method of lifting water by compressed air. It will be noted that the 1-in. air line is inside the 8-in. casing, but outside the 4-in. water line. The 1-in. air line enters into the 4-in. water line through the 4 by 4 by 1-in. tee. A close nipple and a 1-in. ell is connected to the 1-in. air line on the inside of the 4-in. water line with the opening turned up; a 1-in. nipple about 6 in. long is screwed into the 1-in. ell. This connection, shown in dotted lines on the sketch, permits the air to go upwards as it should and not downwards as in the other methods.

A 1 by 1 by ½-in. tee is connected in the air line above the 8-in. pipe flanges. A nipple and a ½-in. stop cock is connected to this tee, also a ½-in. ell, and a piece of ½-in. pipe which is screwed into the flanges which should open inside the casing, but outside the 4-in. water line. This cock should be opened slightly to permit air on top of the water in casing so as to act as a cushion to steady the water.

It should be noted that the immersion should be ⅔ the total height from the bottom of the air line to the level of delivery when the well is in operation. I would suggest that a 4-in. long radius ell be used at the top and that quite a drop be given the 4-in. pipe between the ell and the reservoir so as to get the water away from the well as rapidly as possible. I would also suggest that 1¼-in. pipe be used down to the outside ell so as to carry the initial pressure down to the point of delivery; 1¼-in. pipe has 50 per cent more area than 1-in. pipe,



CONSTRUCTION OF AIR LIFT PUMP WHICH WILL OPERATE ECONOMICALLY

hence there would be a considerable reduction in friction by using 1¼-in. pipe. The full area of the 4-in. pipe is used for the water.

Chicago, Ill. L. Jenkins.

Raising a Tubular Boiler

I have three horizontal return tubular boilers that have to be raised ½ in. at the front end, as ordered by the Inspector. How should I proceed to carry out these orders? W. W. P. S.

A. To raise your three boilers ½ in. at the front end as ordered it will simply be necessary to loosen up the brick work around the shell, down to the level of the supporting lugs, after which a jack may be placed under the front header and the boiler raised the desired amount. It is unlikely that either the steam, feed water, or blow off piping will have to be removed for this purpose. Care should be taken to give the jack plenty of bearing area on the boiler shell so as to prevent its leaving an indentation in the shell. It goes without saying that the boiler should be emptied of water before any moving is done.

POWER PLANT ENGINEERING

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In Memoriam

Warren Gamaliel Harding

Not in public utterances is the measure of a man most clearly revealed, but in his attitude towards the day's work and in his speech of unguarded moments. "Neighbor, I want to be helpful," was the greeting which Warren G. Harding, then Senator Harding, gave to Herbert Hoover, at the time in charge of food conservation. It was in war time. Many were seeking positions of authority in the government organizations. Many were looking for opportunity to achieve prominence in leadership. Harding was in position to do both, and with good grace, for his record and ability warranted it. But the whole nature and thought of the man came to the front. "Neighbor, I want to be helpful."

This may well stand as an epitome of his life and service. No man can desire a better tribute.

Reverently and respectfully we pay homage to the memory of Warren G. Harding, a fellow editor, a far-seeing statesman, a great president and a noble man.

Alinement Charts Simplify Engineer's Work

One of the things that has characterized the work of an engineer is his almost constant use of the slide rule. This, of course, is due to the fact that much of engineers' work of calculation consists in the repeated application of a limited number of formulas to a variety of different conditions, and for this type of calculation the slide rule is admirably adapted.

While the value of the slide rule is by no means to be underestimated, there are many cases where a constant in the formla, or the appearance of unusual powers or roots will complicate solution with the slide rule, and require that extreme caution be exercised. For the solution of such formulas, particularly where the operation is to be repeated a number of times, the use of specially constructed calculating charts is to be recommended. Such charts are usually of two forms, first, the type of chart on which the necessary lines or curves are plotted on rectangular coordinates, and second, the alinement chart, which consists of three or more parallel lines upon which are laid off to some scale the desired factors.

Many excellent examples of alinement charts have made their appearance and there is good evidence of a growing recognition of their value. It is evident, however, that if the engineer is to derive the greatest amount of benefit from the use of the alinement chart, it will be necessary for him to have sufficient acquaintance with their underlying principles, to enable him to construct charts for his own needs.

Beginning in this issue, R. T. Livingston presents the first of a series of three articles, dealing with the practical construction of alinement charts. Mr. Livingston's methods are simple and do not require more than an ordinary knowledge of mathematics. Engineers who have had occasion to use alinement charts and who wish to know more about the methods of constructing them will find Mr. Livingston's articles highly instructive.

Analysis Will Make Charts of Greater Value

Criticism is often heaped upon the head of the engineer who does not demand that his plant be equipped with instruments necessary for efficient operation. In cases where this demand has been made, the owner comes in for his share of abuse until he complies with the engineer's demand.

What, now, is the significance to the engineer when his requests have been met? It is like a boomerang; the owner has side-stepped the whole issue, and left the engineer to prove his assertions.

Right here is where many an engineer has fallen down. He has properly installed and maintained the instruments. He has also improved, by means of them, the plant economy; but he has not analyzed his charts and records in such a way that they will become interesting records and prove interesting and valuable studies to the owner. The owner is a man of broad business experience and while he understands the general requirements as to plant operation he does not know specific details, nor is he in close enough contact with the daily happenings in the plant to draw satisfactory conclusions from a number of charts unloaded on his desk.

He picks up a feed water temperature chart and notes that at 10:30 a. m. the temperature dropped from 210 deg. F. to 160 deg. F. He knows that something was wrong but he cannot explain it. Was the heater taken off for cleaning? Did some exhaust line fail? Did some auxiliary unit fail? These and a dozen other questions may come to his mind; he is busy, he becomes aggravated, all of which contribute to many unpleasant experiences for the engineer.

All of this can be avoided if the engineer will fulfill his duties by writing on the book of charts or attaching notes to them which will explain any unusual conditions. This is also an effective way to keep hammering away at a condition which is not right and which the engineer wishes the owner to become interested in so that advantageous changes may be made.

An analysis and record of conditions will show the owner that the engineer on the job is alert and understands every condition in the plant.

Off Duty

Mark Twain relates a story of a young debutanté who, at a social affair of great brilliance, met the "lion of the evening"—a renowned astronomer. Although considerably impressed by the honor, she hid her excitement well as she chatted gaily for a few moments then, wishing to make an impression, she exclaimed, "—and do you know, I think it just wonderful how you astronomers have been able to find out the very names of the stars."

And that reminds us of the man who, having had Sir J. J. Thomson pointed out as being the discoverer of the electron, and having been told something regarding its extreme smallness, observed that, for an old man, Sir Joseph must have remarkably good eyesight. Now, when you consider that you could crowd more electrons into the space occupied by a single drop of water than there are drops of water in the Atlantic Ocean, we are rather inclined to agree with the man who made the remark.

Whether the discovery of the electron in 1897, however, was due to Sir Joseph's acuteness of vision or whether it was a result of his keen insight (rather than eyesight) into the problem of the constitution of matter, makes little difference insofar as the effect of this discovery on the progress of civilization is concerned. It is sufficient to state that the discovery of the electron by Thomson, and later, its isolation by Millikan, will have a greater ultimate effect on human progress than any other single event in history. We say "ultimate effect" because we have only just begun to realize its importance, although, even in the short span of 10 yr. since its isolation, the electron has had great application. Modern radio telephony is a direct consequence of our knowledge of the electron.

But the future holds even greater promise, and it would, indeed, be presumptuous on our part were we to attempt to limit the possibilities the electron holds in store. Already we are beginning to predict high voltage direct current transmission lines, converting apparatus without rotating elements, vacuum tube circuit breakers, variable speed adjustable frequency synchronous motors, and these are but beginnings. What the electron holds in store for us in the realm of biological chemistry or as a source of possible power supply, exists as yet only as a dream in our imaginations. Even at that, we are not altogether certain that these dreams are only dreams.

Today, the great part of our power supply is derived from a certain chemical reaction known as combustion. When the atoms of oxygen enter into chemical combination with atoms of carbon to form molecules of carbon dioxide, or with atoms of hydrogen to form molecules of water, heat is liberated. This is what is known as the heat of combustion, and it is this heat which we use to convert water in our boilers into steam for whatever purpose it is needed.

Now, the atoms themselves are made up of electrons and protons (protons form the positively charged nucleus of the atom) somewhat in the same way as the molecules of various substances are made up of different kinds of atoms, except that the forces which hold the electrons together in the atom are enormously greater than those which hold the atoms together in the molecule. If, therefore, we could effect a combination between electrons to form atoms similar to the combination of atoms into molecules in the process of combustion, or if, by suitable means, the atom itself could be split up into its component electrons and protons, we should expect the liberation of large quantities of energy.

Indeed, in the spontaneous disintegration of radio-active elements we find evidence of such liberation of energy. The process in this case, however, is extremely slow and the amount of energy available from such disintegration at any instant is small. Furthermore, radio-active elements are rather scarce, and if we now object to paying $10 a ton for coal, what kind of a howl would we raise if we were required to buy radium at $120,000 per gram!

But the electronic forces are not necessarily confined to the radio-active elements, and if a means can be devised for instantly releasing the forces which hold together the electrons in an atom of oxygen or a grain of sugar, and of utilizing such forces, we need not worry about future coal strikes, and all our power supply problems will vanish from the face of the earth forever.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

CO_2 Determined by Means of Electrical Resistance

MEASUREMENT of CO_2 by means of a Wheatstone bridge is accomplished in a new instrument which is being distributed by the Bacharach Industrial Instrument Co., of Pittsburgh, Pa.

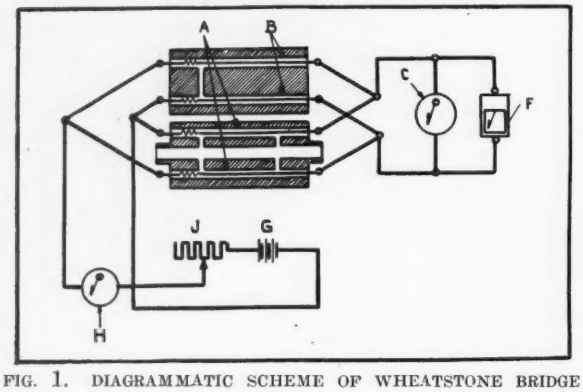


FIG. 1. DIAGRAMMATIC SCHEME OF WHEATSTONE BRIDGE EFFECT

This instrument is known as the S. and H. CO_2 meter, the principle of which is that of the physical property of heat conduction of the gases. The arrangement of the meter is shown diagrammatically in Fig. 1. The system is arranged in a Wheatstone bridge circuit, of which the four branches are the four platinum wires in the two blocks. Across the mid points of the bridge is connected the sensitive indicating galvanometer, C. If desired, the recording galvanometer, F, which may be placed at any reasonable distance from the measuring instrument, can also be connected into the circuit. The electrical energy is obtained from a small storage battery, G, through a variable resistance, J, which is adjusted to give constant current through ammeter H.

Flue gases consist of carbon dioxide (CO_2), carbon monoxide (CO), oxygen, nitrogen, and water vapor, with traces of other gases. Nitrogen, oxygen, carbon monoxide and air have all practically the same heat conductivity, but CO_2 has 40 per cent less conductivity, and water

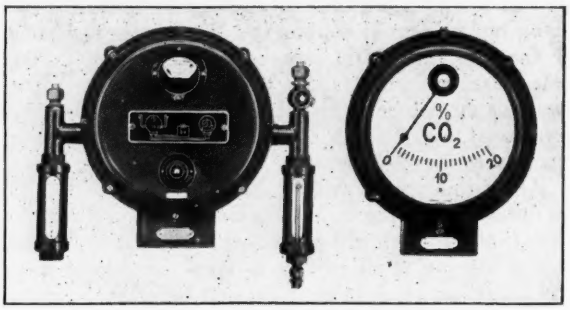


FIG. 3. TWO VIEWS OF NEW BACHARACH CO_2 INDICATOR

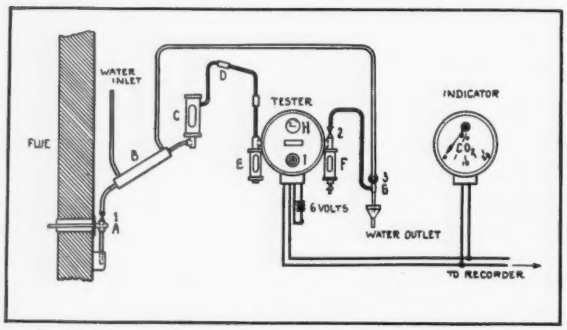


FIG. 2. GENERAL ARRANGEMENT OF CO_2 METER AS INSTALLED FOR OPERATION

"Tester" consists of two sets of blocks, one set containing chambers "A" and the other chambers "B." In the center of each chamber is a thin platinum wire, having at one end a small platinum-iridium spring which keeps the wire always central, regardless of heat expansion. "A" are the measuring chambers through which the flue gas passes slowly; "B" are the comparison chambers, containing air at room temperature. The electrical vapor a conductivity about 30 per cent greater than that of air. The air in the comparison chamber is kept free from water vapor by the presence of hydroscopic chemicals, and the flue gases having passed through a cooler which also acts as a drier, contain a very small, but practically constant, quantity of water vapor, hence the only variation occurring in the heat conductivity of the gases depends directly on the percentage of CO_2 in the flue gas.

As the electric current flows through the platinum wires, the heat which is generated in them is transmitted through the gases to the walls of the chambers. The gases in A, containing CO_2, transmit the heat less readily than the air in B, and the wires in A become hotter than the wires in B; its resistance therefore increases, unbalancing the circuit and causing a deflection of the galvanometer, to an extent depending on the percentage of CO_2 present. The galvanometer is calibrated to read directly in per cent of CO_2. Variations of room temperature influence the two systems of wires A and B in the two metal blocks in the same way and therefore do not affect the proper indication of CO_2, as the electric circuit of the Wheatstone bridge is unbalanced only by the difference in temperature between wires A and B established by the different heat conductivity of the air in the

comparison chambers and the flue gas in the measuring chambers.

In this meter, time lag is practically eliminated. The interval between the drawing of the gas into the sampling tube and the indication of its CO_2 content never exceeds 2 min.

In practice, some accessories are required for auxiliary purposes such as cleaning the gas sample and for drawing it through the measuring instrument. Figure 2 shows diagrammatically the general arrangement. The flue gas sample is drawn through the tube, A, to the cooler, B, in the outer jacket of which circulates water going to the aspirator, G. From the cooler, the gas goes through the soot filter, C, then to the measuring instrument (the tester in Fig. 2). From this tester the gas passes to the aspirator, G. The latter is connected with the cock, 2, to produce a suction of about 1 in. water column above the flue draft, thus insuring a practically constant rate of gas flow. For example, if the flue draft equals ½ in. of water column the manometer, F, should indicate 1½ in. water column. Under these conditions, the gas flow will be fast enough to insure a reasonably quick change of sample, but at the same time the flow will not be so fast as to influence the heat transfer from the wire. The electrical connections lead to the galvanometers, indicating and recording.

This meter may be provided so that it records CO_2, CO and flue gas temperature on the same chart. It may also be adapted to show the per cent of hydrogen in producer gas.

New Stoker Combines Overfeed and Underfeed Principle

A NEW mechanical stoker of interesting design, for all grades of bituminous coal and lignite, has recently been developed by the McClave-Brooks Co., of Scranton,

FIG. 1. COAL IS PUSHED UP INTO THE FIRE BED BY THESE KICKER BARS

Pa. This stoker is a combination of the overfeed and underfeed types. Coal is fed in on top of the grates, yet the method of feeding is such that the fire is completely underfed for a distance of about 2 ft. down the grates.

Sectional-top grates having horizontal air space, are used in order to prevent sifting of fine unburned fuel. The kicker bars are so arranged that in operating there is a complete seal on the heel as well as on the front end of each bar. The kicking movement is automatically controlled, and any kicking position from minimum to maximum can be obtained by a simple adjustment on the front operating shaft. It is also possible to operate the bars in sections, so that any part of the fire can be worked independently of the remainder.

Coal pushers or feeders are operated mechanically, and the length of stroke is not varied in the usual way, but is kept constant. The interval between feedings is regulated by a timer, which enables a variation of the feeding time.

Coal is fed from side wall to side wall, covering the entire grate surface with no intervening spaces and giving little chance for the formation of clinker. A special pre-heated air arch is used, eliminating the need for special arch brick and supplying the requisite amount of oxygen where it is most needed—in the coking zone—to drive off the volatile gases and eliminate smoke.

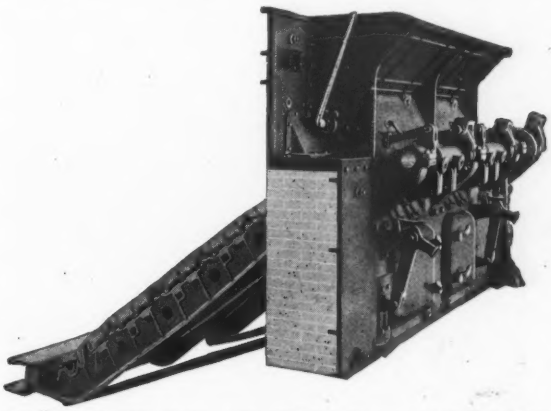


FIG. 2. KICKER BARS ARE OPERATED BY A MECHANICAL DRIVE

Arrangement of the design is such that the stoker may be driven by a steam engine, steam turbine or electric motor, and is equipped with a four-speed gear reduction. In addition, the speed of the driving engine or motor is independently controlled, permitting further variation in operating.

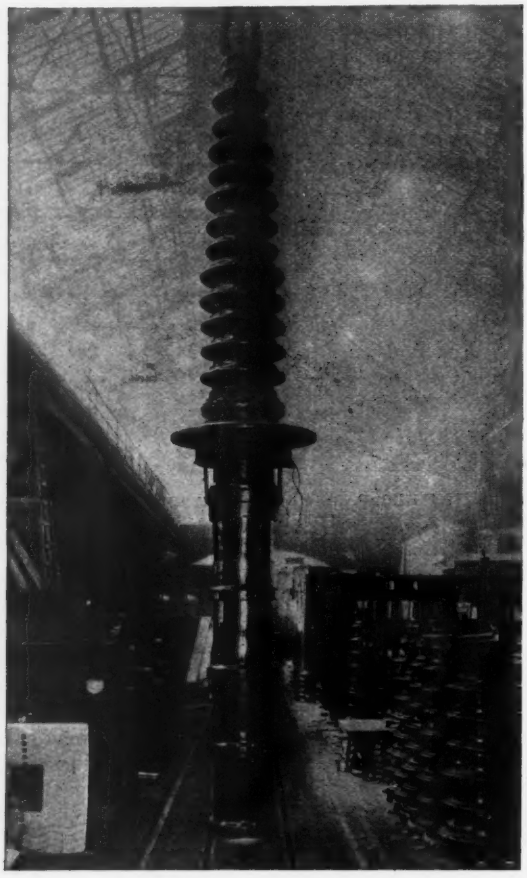
One interesting feature of this stoker is provision made for hand operation in case of emergency. A clutch disengages the power drive and converts the stoker into a hopper-feed hand stoker in a few seconds, enabling manual operation of the coal pushers and kicker bars. This feature permits the stoker to be kept in service despite power failure or other accident to the mechanism.

This stoker is also designed for use in plants where the small number or size of boilers makes mechanical stokers unnecessary. In this case, it embodies all the advantages of the McClave mechanical stoker, except that the coal feeders and kicker bars are manually operated.

GASOLINE PRODUCTION in May amounted to 631,705,000 gal. as against 513,659,000 gal. in May a year ago. Stocks on hand at the end of May totaled 1,328,533,000 gal. as against 856,607,000 gal. on May 31, 1922. Production of kerosene oil amounted to 189,177,000 gal. as against 173,824,000 gal. a year ago, while stocks on May 31 aggregated 272,672,000 gal. as compared with 318,890,000 gal. at the end of May, 1922.

Large Bushing for City of Seattle

IN THE ACCOMPANYING photograph is shown what is probably the largest roof bushing ever manufactured. It weighs 2600 lb., has an overall length of, roughly, 17 ft., and is designed for a normal voltage of 187,000. It is one of four built by the Westinghouse Electric & Manufacturing Co. for the Skagit River Development of the City of Seattle. Three of the bushings



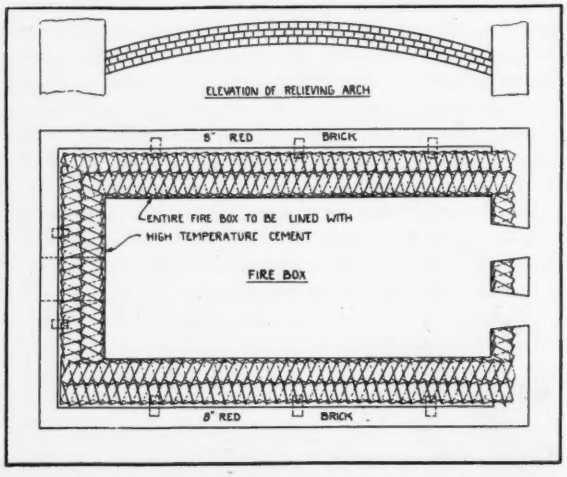
will be used for connecting from a 165,000-v. high tension bus line with a bank of three 10,000-kv.a. single phase transformers and the fourth will be used as a spare. The photograph was taken in East Pittsburgh where the bushings were built.

Herringbone Fire Box Construction

HEREWITH is illustrated a novel arrangement of brickwork for furnace walls designed to prevent loosening and chipping of bricks and to provide a secure holding surface for a high temperature cement lining. As shown, each course has the brick laid at an angle to the surface of the wall, and the two courses at an angle to each other. Courses above and below are laid similarly but with angles reversed, thus giving crossed joints and bearing of each brick on two or three others, adding to stability and avoiding possibility of cracking along vertical joints.

Diagonal ends of the bricks form pockets into which projections of the high temperature cement lining are moulded, thus protecting the surfaces of the brick and giving a large gripping area for the cement.

Tie brick are inserted at intervals from the furnace wall to the red brick setting wall. A relieving arch may be used above the fire box for such part of its length as desired. It will be noted that this diagonal reversed arrangement of courses leaves no continuous vertical air pockets inside the wall, and the inventor, Louis Bernhard, of Boston, who has applied for patent on this



BERNHARD HERRINGBONE FIRE BOX CONSTRUCTION

method of laying up a furnace wall, prefers to fill these inside pockets with high temperature cement to protect the brick and add to stability.

American Engineers to Participate in World Power Conference

IN 1924 American engineers representing engineering and technical societies, business associations, Government agencies and individual companies will go to London for the World Power Conference. Following acceptance by the Executive Board for the Federated American Engineering Societies to be represented at this conference, the following were appointed to the general American committee having charge of plans: Calvert Townley, Fred R. Low and Col. John H. Finney.

This committee met in New York on June 20 to adopt a plan of organization and approval by the delegates present of American participation in the World Power Conference.

Officers were nominated and elected as follows: Honorary chairman, John W. Weeks, Secretary of War; general chairman, O. C. Merrill, executive secretary Federal Power Commission; vice-chairman, H. J. Pierce; members of the executive committee, W. M. Stewart, Calvin W. Rice and Peter Junkersfeld.

THEY SELDOM retrace the trail of success to pat the laggard's back.

A Thirty-Year Review of the General Electric Co.

IN A BOOK recently issued to its stockholders the General Electric Company reviews its growth, and accomplishments during the 30 yr. of its existence. This company, created in 1892, was the successor of the sturdy pioneers of the electrical industry, the Edison General Electric Co. and the Thomas-Houston Electric Company. On Jan. 1, 1893, the outstanding capital stock of the General Electric Co. was about $35,000,000. On Jan. 1, 1923, it was $184,000,000. In 30 yr. the company's annual sales increased from about $12,000,000 to $243,000,000. The value of the company's manufacturing plants increased from approximately $4,000,000 to $167,000,000 and the floor space from 400,000 sq. ft. to over 25,000,000 sq. ft.

An outstanding feature of the company's history has been its success in the fields of scientific research, engineering development, and manufacture. For this, credit is given to the technical accomplishments and inspiring leadership of E. W. Rice, Jr.

From the beginning, the predecessors of the General Electric Co. turned their thoughts to the sources of power on which to build a greater industry in the service of man. Progressive investigation of the problems of power generation on a large scale has continued year after year, and many of the world's most powerful generating units have been constructed in the General Electric shops.

Electric marine propulsion has been a problem to test the finest engineering skill, and it was W. L. R. Emmet, of the General Electric Co., who developed the Curtis turbine, that was responsible for the adoption of electric propulsion of ships. Since 1914, the company has manufactured or is now building propulsion machinery for 400 ships, 30 of which are electrically driven.

To the field of transportation, both for street railway and for the electrification of steam railroads, the company has made numerous contributions. One of the outstanding accomplishments in this field was the remarkable work in laying out the electrification project of the Chicago, Milwaukee & St. Paul Railroad. This is the longest (860 mi.) and perhaps the most impressive main line electrification in the world.

Among the other accomplishments of the company to which the book refers are those contributions to the field of long distance wireless communication, its work in the development of household electrical appliances, electric furnaces for metallurgical processes, its work in the development of the Coolidge X-ray tube, progress in illumination, high voltage transmission, etc.

Brief mention is made of remarkable increase in efficiency of the incandescent lamp, which was the result of two lines of research in the General Electric research laboratories; the one, the perfecting of a method of drawing tungsten into wire by Dr. Coolidge, and the other, the filling of the incandescent lamp with an inert gas, by Dr. Langmuir. If the present day intensity of lighting had been obtained by the use of the carbon lamp of 1892, the cost of lighting in 1922 would have been increased one and a half billion dollars, and there would have been required 25,000,000 T. of coal additional to generate the current for the lamps.

In the latter portion of the book are charts and graphs showing how the money of the company is spent. Out of each dollar of income during the 3 yr., 1918 to 1920, 41.7 cents were paid to the employes as compensation, 40.6 cents were spent for materials and supplies, and the 4.7 cents surplus was used for enlarging plants, inventories, etc.

Tribute is paid to Charles A. Coffin under whose leadership the company was guided along ever broadening paths of usefulness, with a constantly increasing unity of purpose.

Coal Hoist Will Have Capacity of 2000 T. per Hr.

WHAT is said to be the largest coal mining hoist in the world will be installed at Orient No. 2 mine of the Chicago, Wilmington and Franklin Coal Co. at West Frankfort, Ill. A contract for this hoist has been awarded to the Westinghouse Electric and Manufacturing Co. and the Nordberg Manufacturing Co.

At the present time the largest coal mine hoist in North America is one equipped with a hoist motor having a capacity of 1400 hp. and the capacity of the hoist motors of the Orient No. 2 hoist will be 4400 hp. divided in two motors, one mounted at each end of the drum shaft and each having a capacity of 2200 hp. at 40 deg. C. rise.

Coal will be hoisted in skips at the Orient mine, each skip having a normal capacity of 22,000 lb. and a maximum capacity of 26,000 lb. The depth of the shaft is 607 ft. and the coal is dumped from the mine cars at the bottom of the shaft by means of rotary dumps.

A number of unusual features have been worked out for the Orient No. 2 mine, chief among which are the very large capacity and the high rate of hoisting. Under normal conditions, the output per hour will be 1500 T. and under the maximum conditions this output can be increased to 2000 T. per hr.

Operating Cycle of 16 Sec.

Maximum hoisting speed to be obtained will be over 4000 ft. per min. Operation will be at exceptionally high speed, the entire operation of a single cycle from the time the skip starts from the bottom until it reaches the dumping position at the top requiring only 16 sec. This high speed of operation involves very heavy peak loads during acceleration and heavy regenerative loads during retardation. The actual load during acceleration is about 8000 hp. and the regenerative load during retardation about 4000 hp.

Power will be supplied to the hoist motors through a flywheel motor generator set, equipped with two 1800-kw., 600-v., 600-r.p.m. commutating pole, compensated wound direct current generators driven by a 2200-hp., 2200-v., three-phase, 60-cycle, 600-r.p.m. wound rotor induction motor. The motor generator set is to be equipped with a 90,000-lb. flywheel 12 ft. in diameter and built up of steel plates.

Control for the hoist will be thoroughly provided with safety devices and automatic acceleration and retardation are included. All possible contingencies are to be provided for so that it will be practically impossible for trouble to occur due to careless operation or

wrong manipulation of the hoist and brake levers by the hoist operator. In case the operator should be incapacitated at any time, the hoist will automatically slow down and come to rest without causing any damage whatever to the equipment.

Value of Low Temperature Distillation of Coal

ONLY thorough trial on a large scale and at a great cost can determine the worth of Henry Ford's project for low temperature carbonization of coal on a commercial basis, according to Dr. Jerome J. Morgan, member of the American Chemical Society, and professor of chemical engineering in the Schools of Mines, Engineering and Chemistry at Columbia University.

Wide interest among American chemists and manufacturers has been aroused by Mr. Ford's venture, which aims to bring about drastic economics in fuel. In response to a request for his view of the possibilities of the experiment, Prof. Morgan said:

"Discussion of the reported erection of a large plant by the Ford Motor Co., at River Rouge, for low temperature carbonization of coal draws attention to a problem that has in the last few years been of great interest to students in fuel economy.

"In any discussion of low temperature carbonization of coal certain fundamental principles in fuel utilization must be kept clearly in mind.

"First: A pound of coal represents a certain amount of latent chemical energy. Expressed in heat units for an average bituminous coal of medium ash and moisture content, this is roundly 14,000 B.t.u. per lb. This represents the total energy that can be obtained from this pound of coal. No method of treatment can possibly add to this amount of energy.

"Second: Any process of carbonizing coal consumes energy which must be supplied from the energy originally present in the coal or as is so often done in the laboratory from some outside source. Hence, a carbonization process is justifiable only when the value of the products of carbonization is greater than the value of the raw coal. In ordinary high temperature carbonization of coal in a gas retort or coke oven the main products are coke and coal gas.

"Third: In low temperature carbonization of coal there is obtained semi-coke, gas, ammonium sulfate and low temperature tar. The semi-coke is not suitable directly for metallurgical fuel; in most cases it requires subsequent treatment for domestic fuel and there is only about three quarters of a pound of it per pound of coal. The gas from low temperature carbonization, though richer than ordinary coal gas, is in much smaller amount, and there is only about half as much ammonium sulfate formed as in high temperature distillation.

"Fourth: In considering the value of low temperature coal tar there are many factors which must be balanced. The amount obtained is considerably greater, often two or three times greater than that from high temperature distillation of the same coal. Its value, however, in the present market is rather doubtful. Since it represents the first step in the decomposition of coal, its composition varies much more according to the nature of the coal than does the composition of high temperature tars.

"Many of the current claims for low temperature tars are based upon work done in Germany on tars from Germany brown coals which differ greatly in nature from American coals. This dangerous practice of reasoning by analogy has led to the publishing of many misleading statements.

"Fifth: Finally, whether any proposed process for low temperature carbonization is a commercial success can only be determined by the balance sheet of a plant which has actually been operated on a large scale for a considerable period of time."

News Notes

TWO OF THE LARGEST power companies in Maine will link up their plants so that current may be interchanged in case of emergency in either company. These are the Central Maine Power Co., of Augusta, and the Cumberland County Light and Power Co., of Portland. The two companies serve between 80 and 85 per cent of the electric users in the state of Maine. Surveys and engineers' plans have been completed and the work of making the physical connections will commence at once and it is expected that before fall the connections will be completed. Need of such emergency measures was demonstrated during the floods in the central and eastern part of the state last spring when the current of the communities was entirely shut off for a period of from a week to two weeks. Had the two companies been linked together at that time, there would have been practically no curtailment of power.

WILLIAM J. MERTEN, metallurgical engineer of the Westinghouse Electric and Manufacturing Co., has been appointed a member of the Committee on Heat Treatment of Carbon Steel of the National Research Council and has also been elected chairman of the Pittsburgh chapter of the American Society for Steel Treating.

Both honors have been given to Mr. Merten because of his accomplishments in the metallurgical field and are evidences of recognition of his work by metallurgists and metallurgical organizations. His appintment to the Committee on Heat Treatment of Carbon Steel of the National Research Council, which is also known as the Henry M. Howe Committee, is for a period of three years and his election as chairman of the Pittsburgh chapter of the American Society for Steel Treating is for the ensuing year.

MCCLAVE-BROOKS CO., Scranton, Pa., has appointed the Carbondale-Buffalo Co., Buffalo, N. Y., as its sales representative in New York state and Canada. The territory will include that part of the state west of Rochester, and also provinces of Ontario and Quebec in Canada. Henry J. Botchford is manager of the Carbondale-Buffalo Co. I. N. Beeler Co., 504 City Bank Building, Syracuse, N. Y., will represent the McClave-Brooks Co. in New York state north of Kingston and east of Rochester. Sales in the remaining part of the state will be handled by the McClave-Brooks Co.'s branch office in New York City, under the direction of George Blair, Jr. Norris R. Sibley was recently appointed assistant manager of the New York office.

KERR TURBINE COMPANY of Wellsville, N. Y., has just undergone a reorganization through the acquisition of

practically all its common stock by new interests. Paul B. Hanks, the former president, having disposed of his holdings, has resigned and has been succeeded by W. T. Hamilton of Pittsburgh, Pa. Mr. Hamilton has associated with him a number of well known engineers and experienced manufacturers. Ample capital for expansion has been put into the business of a sufficient amount to take care of all the present and future requirements enabling the company to take care of any volume of business that may be developed in its line of manufacture.

JOHN S. ISDALE has resigned from the position of electrical engineer to the New York Harbor Drydock Co., Inc., Rosebank, N. Y., to become sales manager of the Marine Products branch of the Horne Electric and Manufacturing Co., Jersey City, N. J.

CARL J. SITTINGER, formerly engineering manager for the Bethlehem Loading Co. of May's Landing, N. J., and for the past 4 yr. associated with John A. Stevens, consulting engineer, of Lowell, Mass., has entered the electrical division of Stone & Webster, Inc., of Boston.

A. S. MOODY, ASSISTANT Northwest manager of the General Electric Co., has been appointed local manager of the Los Angeles office of the company, to succeed R. L. Cash, who has been transferred to Schenectady. Mr. Moody is well known in the electrical industry on the Pacific Coast, having been identified with the General Electric Co. in that section for the past 16 yr.

UNITED ELECTRIC LIGHT CO., of Springfield, Mass., has secured a permit for the construction of a new power house to be constructed on Page Boulevard near Rumwill Road, the building without equipment, to cost $30,000. McClintock & Craig are architects and L. S. Wood has the general contract. The new plant will be used as an additional generating plant to the present one.

FARR ALPACA CO., of Holyoke, Mass., will start at once upon the construction of additional plants for power purposes for its mills in that city. Two new buildings will be erected, the first to house boiler equipment and the second to contain a steam turbine plant, the former to cost $150,000 and the latter $40,000 exclusive of equipment. The estimated cost of the new power plant and equipment is $1,000,000.

CHARLES H. TENNEY CO., of Boston, have plans under way for the construction of extensive additions to the electric generating power plant at Salem, Mass. It is understood, however, that these plans call for the gradual extension of their generating facilities and that development of the plans will extend over a period of years.

In this connection, the company has just purchased the Phillips Wharf property together with a number of parcels of adjacent property which adjoin their present plant at Salem. This purchase contains about nine acres along the Salem water front.

CONNECTICUT BLOWER CORPORATION, Hartford, Conn., has been incorporated under the laws of Delaware with capital of $250,000; M. E. Keeney, president; C. H. Keeney, treasurer; C. E. Keeney, secretary. They have taken over the International Blower Co. and the Hartford Sheet Metal Works. The products manufactured and installed are of a large variety, such as blowers and exhaust fans, blower systems of all kinds, dust collecting systems, exhaust systems, ventilating systems, etc. The plant of the International Blower Co. will be utilized until fall at which time a considerably larger plant will be occupied.

HYDRO-ELECTRIC POWER COMMISSION of Ontario has recently placed an order for two 58,000 hp. water turbines to be built by the Dominion Engineering Works, Ltd., Canadian licensees of William Cramp & Sons. Three other units, now in operation for the Commission, which were built in the Cramp, I. P. Morris shops were imported into Canada. One of these was recently selected by the Commission engineers for an efficiency test. Results showed an efficiency, under designed full load, of 93.4%; and the average efficiency throughout the full range of load, is believed to be the *highest ever attained* in any prime mover.

BUNDY STEAM TRAP CO., Nashua, N. H., announces the appointment of sales representatives as follows: Sixt & Day Specialty Co., Guardian Bldg., Cleveland, O., and H. M. Bush, 20 South 3rd St., Columbus, O.

PRELIMINARY grading for the construction of a $1,000,000 unit for the General Electric switchboard manufacturing plant at Sixty-eighth St. and Elmwood Ave., Philadelphia, has begun. The plant is the first of a series to be erected on 20 acres of property acquired recently.

Officials of the company state that the work probably will mean a total development in that neighborhood of between $8,000,000 and $10,000,000 during a number of years. The first unit probably will be completed within seven or eight months.

ARKANSAS LIGHT & POWER CO., of which H. C. Cough is president, has contracted with Ford, Bacon & Davis, of New York, for the construction of the first of a series of power dams and electric generating stations to be built on the Ouachita River in the vicinity of Hot Springs. The first dam will be built at the mouth of Cove Creek, 15 mi. southeast of Hot Springs, at a cost of $1,500,000, and will develop 15,000 hp., and is expected to be completed within 18 months.

CONTRACT for construction of the Long-Bell Lumber Company's new power plant was awarded recently to the Charles C. Moore Co., of San Francisco. Work will commence at once. A reinforced concrete building is to be erected between the mills. Two stacks 300 ft. high and 50 ft. in diameter at the base and 21 ft. in diameter at the top are included in the contract. The cost is unofficially estimated at $2,000,000. The plant will supply power to the mills, the city of Longview and logging camps. Ultimate development of 20,000 hp. is expected.

UNITED STATES Civil Service Commission announces open competitive examinations for the following positions:

First Class Steam-Electric Engineman, $1600 to $2000 a year; Second Class Steam-Electric Engineman, $1200 to $1700 a year; Third Class Steam Engineman, $600 to $1200 a year. In addition to salaries named, the increase of $20 a month granted by Congress will be allowed. Receipt of applications will close Sept. 18.

Books and Catalogs

A SYMBOL OF SAFETY, by Harry Chase Brearley. First edition, 6 by 9 in., cloth, 290 pages, 81 illustrations; Garden City, New York, 1923.

This is an interpretative study of a notable institution organized for service—the Underwriters Laboratories. It gives a popular exposition of the many functions of this organization, and its relationship to industry.

Like many other important influences of American life, the Underwriters Laboratories was, in a way, an outgrowth of the World's Fair in 1893. In that year, Wm. H. Merrill came to Chicago to serve as an electrician of the Chicago Underwriters' Association, his special task being that of solving some problems in connection with automatic fire alarm service in Chicago and of inspecting the electrical installations at the World's Fair. He brought with him the laboratory idea that was later to germinate. Certain tests were found necessary and a small room was taken on the third floor of the Fire Insurance Patrol Station No. 1. Here, above the horses of the salvage corps, were installed a bench, a table, some electrical measuring instruments and a few chairs, the whole plant representing an investment of about $350. The staff consisted of Mr. Merrill, one helper and a clerk. Thus began an activity which in 30 yr. has grown to embrace the services of 200 engineers, 250 outside inspectors, a plant containing 55,000 sq. ft. of floor space, with branch laboratories in New York, San Francisco, a Canadian organization, and offices in 141 cities with a connection in London.

The story of this organization is one of great interest and the author evidently was given every opportunity to make a thorough study of its work. The book conveys some idea of its extent, its diversity and significance. Numerous full page plates, illustrate the thousand and one activities of the organization, and show, better than words could, the methods used in solving difficult problems.

INGERSOLL-RAND CO., 11 Broadway, New York, has just issued a new 36-page bulletin describing its "Imperial" Type XPV Steam Driven Air Compressors. This type of compressor is built in a number of different types and sizes. Standard two-stage machines for 100-lb. discharge pressure, range from 246 to 4150 cu. ft. per min. piston displacement. Single-stage compressors are built for furnishing air up to 50-lb. discharge pressure. In their bulletin, the manufacturers call particular attention to the steam valve gear which is used on these compressors. This consists of completely balanced piston valves with riding cutoff valves which telescope within the main valves. Such valve gear will operate under any commercial steam pressure or degree of superheat and has proven to be very satisfactory on low or high-speed steam driven compressors.

One of the outstanding features of Type XPV compressors is the automatic cutoff governor which regulates the compressor. This governor is operated by means of oil pressure and performs automatically three functions; maintains constant air pressure regardless of the air demand, regulates the steam cutoff to take care of varying steam conditions, and adjusts the speed of the compressor to the demand for air and prevents the compressor from exceeding the maximum safe limit.

CROLL-REYNOLDS ENGINEERING CO., of New York City, is distributing bulletin E, which describes the heater for feed water, domestic and industrial purposes and also the line of coolers built by this organization.

COMBUSTION ENGINEERING CORP., of New York, is distributing a pamphlet on the type K stoker for operating boilers ranging up to 200 hp. The method of operation and the important features of the stoker are described.

"CLEAN STEAM from Your Boilers" is the title of a new descriptive bulletin which the Andrews-Bradshaw Co., Pittsburgh, Pa., is distributing. The bulletin contains information on the effects of wet and dirty steam from boilers and limitations of feed water treatment.

PROGRESS IN the development of electric steel casting work, the advantages of this method and the results which have been achieved are discussed in a series of bulletins issued by the Nugent Steel Castings Co., of Chicago. Among the various types of castings mentioned which have been successfully handled with electric steel is the serpentile boiler header.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has issued two new catalogs on electric lighting equipment: Catalog 8-A, on Overhead Street Lighting Equipment, and Catalog 8-B, on Ornamental Street Lighting. The first catalog contains 72 pages and the second 68, and both are fully illustrated with photographs and line drawings. In addition to the lighting equipment itself, the catalogs contain a complete descriptive list of accessories such as cables, potheads, mast arms, cut-out pulleys, etc.

IN A 56-PAGE bulletin, the Sturtevant Co., of Hyde Park, Boston, Mass., describes its type 12 steam turbine. Part one gives in detail the construction of the various parts, illustrated by photographs; it also suggests applications where such turbines can be used. Part two is on the care and operation of the turbines, embracing such paragraphs as lubrication, bearings, adjustments and points to remember. In this part also, dimensions are given. Part three shows disassembled views and cross-sections with every part properly listed and numbered.

MCLEOD & HENRY CO. of Troy, N. Y., manufacturer of furnace refractories, has just published Bulletin 156 on "Steel Mixture" Fire-Box Blocks, Veneer Lining and Boiler Door Arches. This bulletin describes in detail the causes of deterioration in furnace lining, shows how old furnace linings may be rebuilt for better service and longer life, and explains the very latest furnace construction that reduces labor, time and material costs in making lining renewals in every type of boiler. It is fully illustrated with photographs and two-color diagrams of correct constructions for boiler settings, and is of value to every man in charge of steam boiler furnaces.

ROSS PRESSURE REGULATING valves and feed water filters are described in a bulletin issued by the Ross Valve Mfg. Co., of Troy, N. Y. The filter described is for use in removing oil from feed water and is connected between the feed pump and the boiler.